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# THE RESTORATION OF DEFECTS IN THE SKULL

## WITH SPECIAL REFERENCE TO THE MANAGEMENT OF INTRINSIC TUMORS OF THE SKULL AND CERTAIN TYPES OF LOCALIZED OSTEOMYELITIS

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LARGE defects in the skull are a constant source of apprehension to the patient, and in some degree are a source of real danger. Apart from this aspect of the situation, defects which are not concealed by the hair, such as those involving the regions of the forehead, are extremely deforming and unsightly.

Interest in the repair of such defects was aroused during and after the Great War by the large number of patients for whom such reconstruction was desirable. During this postwar period, numerous reports of technical methods of repair and accounts of series of cases were published, but nothing radically new was evolved.

The implantation of grafts of rib cartilage from the same person, osteoperiosteal grafts to the skull from the tibia, portions of the ilium and the scapula were used. Heterografts of dead and sterilized cranial bone were transferred to the living. For small defects, trephine buttons from the outer table of neighboring bone were used to fill the gaps, and for larger areas, the outer table of skull, with pedunculated flaps of periosteum and pericranium, was chiseled off and swung into the area of the bony defect. In some cases, the rough surface was placed in apposition with the dura and, in others, it was turned toward the scalp.

A survey of the literature to determine the fate of such grafts leaves one with the wish that there were more reports of their ultimate condition. Detailed information on regeneration and absorption of bone is scanty. Conclusions drawn from experimental and clinical studies on long bones are not applicable to the skull, and very little experimental work on the skull has been done.

My own experience with strips of bone and periosteum from the tibia and with grafts from the outer surface of the skull indicates that the grafts may become solid, but that absorption of calcium progresses until the density of the graft is such that it may no longer be seen in the roentgenogram.

Deformity does not necessarily recur, although some depression returns. In place of the absorbed graft, a fibrous layer of sufficient density and firmness may remain and continue to be highly satisfactory in a cosmetic way as well as affording sound protection.

Regeneration of bone in the skull amounts to little. The opportunities to observe this after injuries and operations are numerous. Fine fissured fractures of the skull may show no roentgenologic evidence of their presence after a few months, and yet we have known a fissured fracture 1 Mm. across to persist for five years.

After osteoplastic craniotomy, the bone flaps may show bridging of bone, but the union is largely one of fibrous tissue. Trephine and perforator openings show rounding of the cut edges with the production of a small amount of new bone, but not enough to obliterate the space, which becomes filled with dense fibrous tissue.

Even careful subperiosteal craniotomies, as in the cerebellar operations on children, are not followed by the reformation of normal skull, although plaques of bone, the thickness of an eggshell, are developed at the site.

FIG. 1.—Osteoma of the skull, before operation.

Extensive grafts of bone are time consuming. Insofar as defects in the skull can be avoided, this should be our aim. When defects are anticipated, some planning on the part of the surgeon will often permit immediate filling of the gap and will avoid secondary operations. Certain procedures have been developed in our clinic which have enabled us to avoid defects in some, and to simplify the repair in others.

Such defects of the skull are seen commonly following depressed fractures when the removal of fragments has been necessary in the interests of cleanliness; but a considerable number result from the removal of tumors involving the skull itself, or the occasional osteomyelitis of a bone flap following craniotomy.

The removal of a bony tumor of the skull usually has necessitated the sacrifice of the involved bone so that a defect of varying size remained and operation later was necessary for the repair of the defect.

Some years ago I was consulted by a woman because of an unsightly protuberance on the right side of the forehead between the eyebrow and the hairline. It extended laterally to the margin of the temporal fossa. Roentgenologic studies confirmed the diagnosis of an osteoma. By an appropriate coiffure, the prominence could be concealed fairly well, and no surgical treatment was advised. After a lapse of some two or three years, it became apparent that, because of the progression of the growth, it would shortly reach the frontal sinuses. During this time it had extended in other directions, and increased in prominence. It reached the hairline above, and into

the anterior margin of the temporal fossa laterally. Because of its appearance (Fig. 1), the patient was quite insistent that it be removed. It was apparent that the usual procedure of complete removal of the involved bone would leave a defect which would be far more unsightly than the protrusion caused by the tumor itself. If, however, the tumor extended farther, it soon would reach the frontal sinus and complete removal would then involve the risk of infection. Some means, therefore, was sought to overcome the objectionable features of the removal. The tumor was situated in the area of bone which customarily is reflected in an osteoplastic flap to approach the pituitary region. The feasibility of making such an osteoplastic flap, removing the tumor from the bone and devitalizing the bone by heat, suggested itself. It was finally decided that complete removal of the flap and restoration of the contour of the outer table by removal of the tumor with chisel and raspatory would be sufficient, and that the deprivation of circulation to the bone, which would be involved in its temporary removal, would be such as to prevent recurrence of the growth. The possible need for boiling the bone flap was considered, but this procedure was not adopted because it was thought that the coagulation of proteins within its substance would make it less readily tolerated by the surrounding tissues.

FIGS. 2 and 3.—Postoperative appearance (osteoma of skull).

**Case 1.**—On February 10, 1928, a scalp incision was made of a type which has been in vogue in this Clinic since 1923. It began in the natural midline vertical crease of the forehead, about 2.5 cm. below the hairline. It continued directly up into the hairline, and almost parallel to the longitudinal sinus for a distance of 4 cm., then turned in a gentle curve down to the temporal region, just in front of the ear. The scalp and the aponeurosis of the occipitofrontalis were dissected forward, and reflected down to the region of the frontal sinus and close to the orbital ridge. An osteoplastic bone flap then was made as for intradural procedures in this region. The hinge of

the flap was placed in the right temporal fossa, and the perforator and burr openings were so located that, when connected with the Gigli saw, the entire tumor would be included in the flap. Small fragments of bone and bone dust were retained, as is our custom, for later filling in of the openings made by perforator and burr. When the bone flap was removed, the contour of the inner table was found but slightly altered and was restored by smoothing the bone. The major portion of the mass projected from the external table to the size of half an egg. With small sterile vise, raspatory and chisels the growth was removed and the contour of the skull was restored and smoothed with but little difficulty. After thorough washing with Ringer's solution, the bone flap was replaced, the perforator and burr openings were filled with bone chips and dust, and the aponeurosis and scalp were sutured in place with interrupted

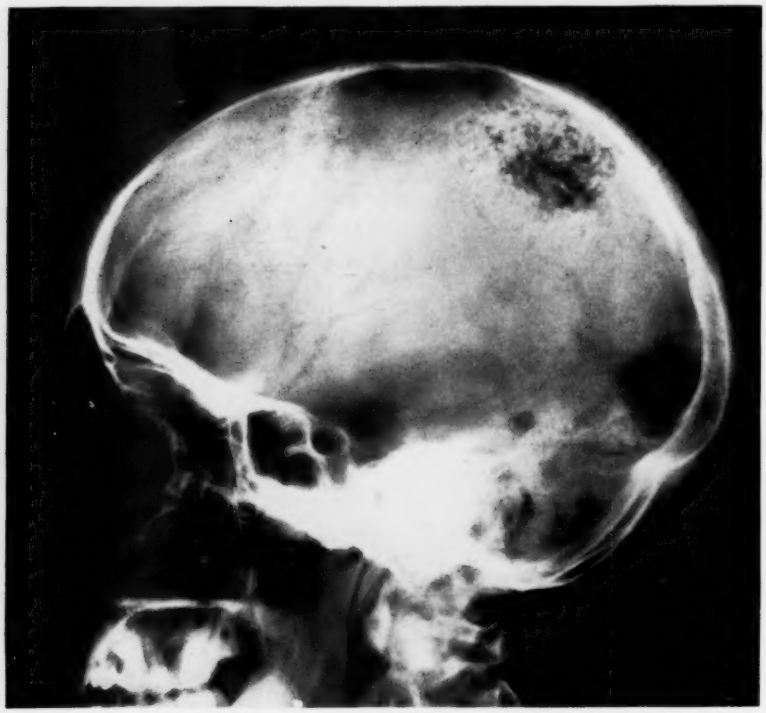

FIG. 4.—Roentgenogram of granuloma of the skull, before operation.

sutures of fine black silk. Convalescence was uninterrupted and healing was prompt and without reaction. The cosmetic result was regarded as perfect (Figs. 2 and 3). At intervals over the succeeding years, roentgenologic examinations of the area have been made, but there has been no evidence of any return of the growth, and little or no alteration has occurred in the appearance of the bone flap. In contrast to later cases in which the bone was boiled, this replaced unboiled bone shows no evidence of absorption or of sclerosis.

This experience, and the applicability of the method to other conditions encouraged us to broaden its field of usefulness. The rôle of the bones of the skull is quite different from that of bones in other parts of the body. The skeleton of the trunk and the extremities is supporting in function and provides attachments for muscles and ligaments. In the skull, the rôle of a framework to provide attachments for muscles is a minor one, but as a bony

case, the skull protects the cranial contents. In this manner the skull of the human being resembles the shell of the arthropods in that it surrounds the structures which it serves. The unimportance of the bones of the skull as far as the attachment of muscle is concerned, affords unusual opportunities for the treatment of neoplasms which are primary in the bone.

In the body generally, if the tissues harboring a neoplasm could be removed, the neoplastic cells killed, and the tissues serving as host to the tumor returned to the body to continue their function, the accomplishment would be ideal. Such management has proved possible in the skull, and tumors of the skull have been so treated in recent years. An ample margin of normal bone is allowed between the tumor and the area of resection. The entire area of involvement then may be removed and studied; sections for pathologic study may be obtained, and roentgenograms and photographs secured;

FIG. 5.—Granuloma of the skull at operation.

FIG. 6.—Photograph of area removed at operation for granuloma.

following this, the excessive soft tissue can be removed, the contour of both surfaces of the skull restored and, after sterilization by boiling, the bone flap can be replaced and the scalp resutured. The patient is thus left without a defect in the bone to be repaired later.

**Case 2.**—A patient presented himself at the University Out-Patient Dispensary because of an irregularity of the skull which he noted following an injury to his head sustained during a football game. At the time of his original injury, there had been no loss of consciouness and the game had been resumed. Some time afterward, an irregularity could be noted in the right posterior parietal region, near the parietal eminence, and as this became more marked, he sought medical advice. Upon palpation, a distinct crater could be felt, with hard edges about it. The outer surface of the bone seemed raised. It was felt that he had sustained a depressed fracture. Roentgenologic examination, however, showed a curious lace-like, moth-eaten appearance of the bone, the central area being almost destroyed, but with evidence of some proliferation of the

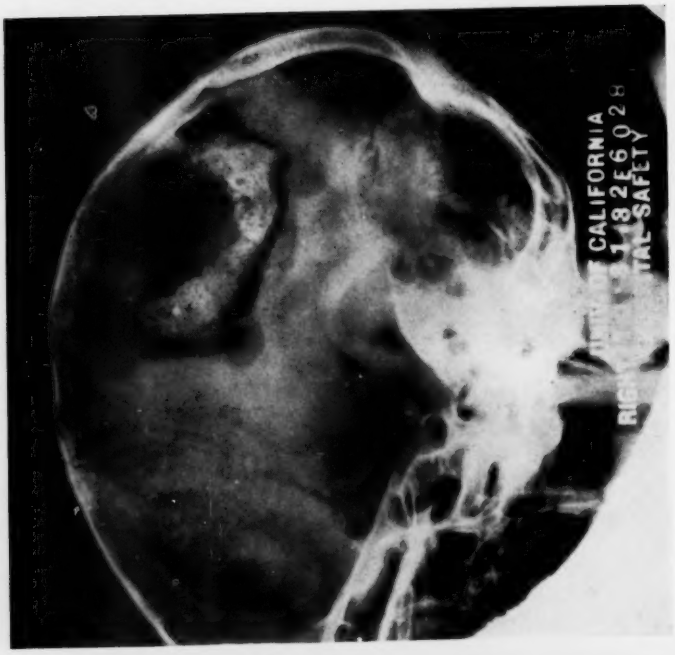


Fig. 8.—The amount of absorption of bone seven and one-half months after operation.

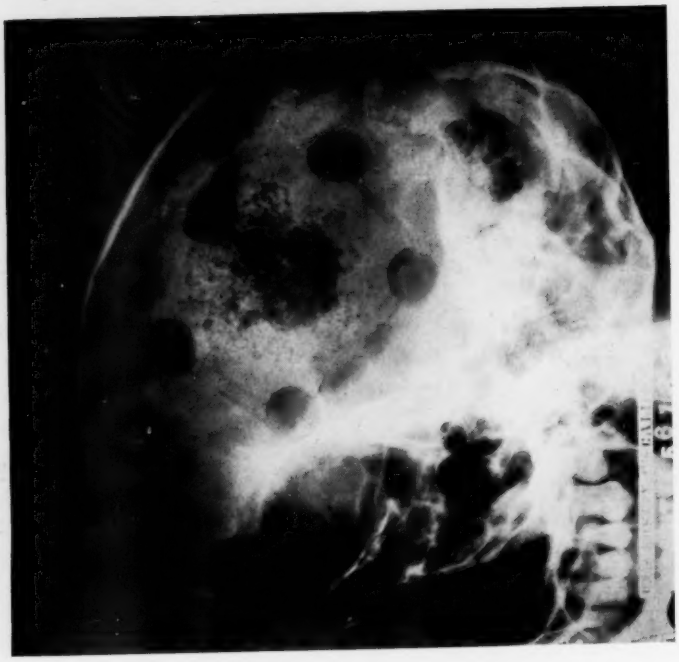

Fig. 7.—Roentgenogram showing the appearance of the replaced bone after sterilization.

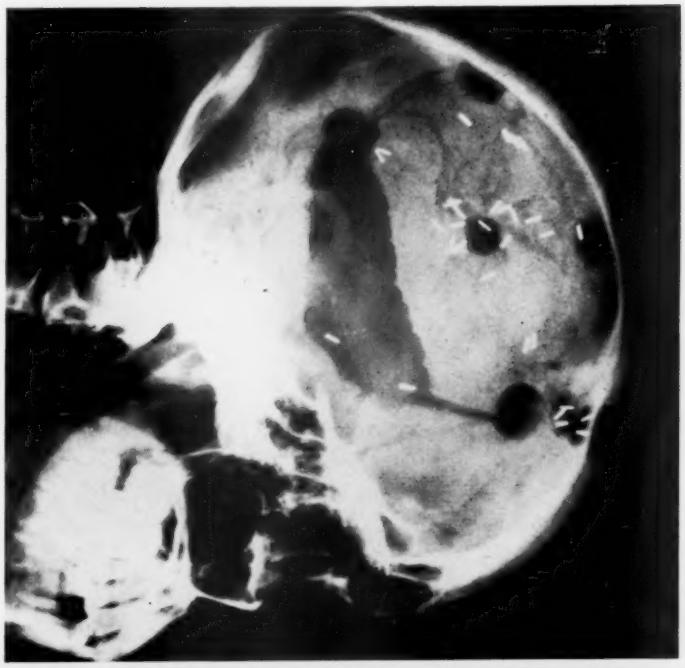

FIG. 9.—Roentgenogram of the bone flap shortly after operation (case of endothelioma).

FIG. 10.—Appearance of replaced bone flap one year after operation (case of endothelioma).

bone as well as destruction of it about the margin (Fig. 4). Complete removal of the affected area would have left a huge defect of the skull.

At operation, the surrounding scalp was turned back in a large flap. The bone was exposed, and a crater 3 or 4 cm. across the center, filled by granulomatous material, was uncovered (Fig. 5). Perforator and burr openings were made at a considerable distance from the area of involvement and connected by a Gigli saw. The bone flap was removed, photographs (Fig. 6) and roentgenograms were taken, pathologic examination of the material was obtained and, after restoration of the contour of the bone, it was replaced and the scalp sutured. Healing was uneventful and there have

FIGS. 11 and 12.—Photographs showing the area of defect in the bone (case of postoperative osteomyelitis).

been no sequelae. The pathologic diagnosis on the tissue was that of a granuloma of unknown origin. Follow-up films of this replaced bone show progressive absorption (Figs. 7 and 8). Examination of the patient shows a little more depression of the area at the site of operation, but a firm support between the scalp and the dura.

Among neurologic surgeons, it is a common experience to find that the meningeal growths usually known as endotheliomata or meningiomata show a tendency to penetrate the dura and involve bone. A visible and palpable tumor frequently overlies such a growth and, in the past, complete removal of the neoplasm ordinarily has required a sacrifice of all invaded bone to prevent recurrence. Following operation, the defect in the skull often is the patient's major concern. If such invaded bone is removed en bloc, it can be treated as in Case 2. Boiling for a few minutes seems adequate for the complete destruction of all viable cells. Later roentgenograms, in one of our

cases in this group, show smoothing off of the margins of the replaced flap and spotty areas of absorption of bone (Figs. 9 and 10). Satisfactory management requires rigorous asepsis; without it one is doomed to failure.

Even in the hands of the most careful surgeons, craniotomies occasionally are followed by infection of the wound. Such a happening of course will

FIG. 13.—Appearance of the patient after replacement of the bone flap (case of postoperative osteomyelitis).

involve the immediate sacrifice of the replaced bone. On the other hand, our experiences have been a help when dealing with an infected wound after an osteoplastic craniotomy. In the following case infected bone was removed, the infection treated and later the bone was reimplanted.

**Case 3.**—Mrs. H. entered the University of California Hospital in September, 1931, complaining of failing vision and bitemporal hemianopsia. Investigation revealed that she was suffering from a pituitary adenoma of the chromophobe type, and operation was advised. A scalp incision of the type described in Case I was used, the scalp was reflected, a right osteoplastic flap was fashioned, and the removal of a chromophobe adenoma of the anterior lobe of the pituitary gland was accomplished. The immediate convalescence was uneventful. The sutures were removed on the fourth day. On the eighth day, a slight purpling of the scar, with fluid underneath, indicated the retention of a small amount of old blood. Puncture and aspiration revealed old blood containing a few clumps of pus cells. In spite of conservative measures, it became apparent that an extensive removal of bone would be required.

Under such conditions, the osteomyelitis usually is confined to the flap rather than

to the surrounding bone. Attempts to clear up such infections by removal with the rongeur of the neighboring portion of the bone flap must be done rather radically if the infection is to be checked, and not infrequently such a procedure is doomed to failure so that ultimate sacrifice of the entire flap is necessary. With such knowledge in mind, and with our experiences in such conditions as those mentioned above, it was considered the part of wisdom to remove the entire bone flap. The scalp was opened and the flap was taken out. The wound was irrigated thoroughly with Ringer's solution and the scalp was closed after inserting a small drain. Healing was prompt. The flap which had been removed was thoroughly washed, sterilized, and preserved for future use. In the meantime, the patient suffered from a most unsightly depression of the forehead, and the caving in of the scalp immediately above the frontal sinus was

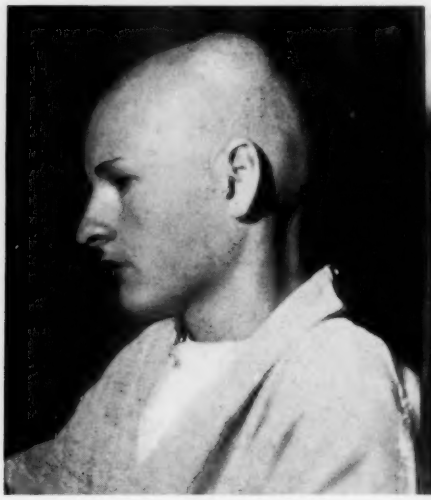

FIG. 14.—Tumor of the skull, before operation.

FIG. 15.—Appearance of the patient after operation (case of tumor of the skull).

most disconcerting (Figs. 11 and 12). A period of months elapsed during which time the wound remained completely healed without indication of infection. During the latter part of this time, the scar and surrounding area had received rather vigorous massage, without any inflammatory reaction resulting.

The wound was reopened, the rounded margins of the skull surrounding the defect were removed, and the edges freshened. The preserved bone flap, which had been reboiled, was fitted accurately into place, the perforator and burr openings were filled with small chips and the scalp was replaced and closed with layers of interrupted black silk for the galea and skin. Because of the tightness of the scar at the posterior edge, there was slight retraction, with exposure of the bone beneath over a tiny area, and for a short time we feared that this would prevent complete healing. A minor plastic operation on the scalp in this region, however, completely covered the area, healing of the wound was prompt, and there was no infection. The contour of the forehead was restored to normal and certainly no plastic operation of any of the usual types could have approached such a cosmetic result (Fig. 13). Later roentgenograms show some absorption of the replaced bone, but no recurrence of the deformity.

**Case 4.**—Recently a young girl presented herself because of a smooth, firm, nontender tumor over the parietal eminence (Fig. 14). The growth had been progressive over two and one-half years. Roentgenologic studies showed what was diagnosed as a chondroma (Fig. 16). Removal of the area and surrounding normal bone in one

piece was effected. The excess tissue was removed, the bone boiled, and the flap replaced at one sitting. The growth proved to be composed of dense fibrous tissue and bone—a fibroma durum. Healing was uncomplicated (Fig. 15).

For such operative handling of the intrinsic primary tumors of the skull, or for secondary bony invasions from neighboring tumors, and in selected

FIG. 16.—Roentgenogram of tumor of the skull, before operation.

cases of osteomyelitis, particularly of the postoperative type herein mentioned, such procedures have given a new direction to the surgical problem. The ability to remove tissue harboring a tumor, to destroy the viability of the tumor and to replace the tissue which acted as its host, is of interest.

In the management of recent depressed fractures of the skull with badly contaminated open wounds of the scalp, the surgeon often is forced to sacrifice considerable areas of bone to prevent infection. In such cases, it is entirely practicable to save the larger pieces for replacement at a later date. In operations for closed, depressed fractures, whether soon after injury or at a later time, bone may be replaced at once after elevation.

# COMPARATIVE STUDIES ON TRAUMATIC SHOCK UNDER ETHER AND UNDER SODIUM AMYTAL ANESTHESIA

AN EXPERIMENTAL RESEARCH

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FOR a number of years sodium amytal has been used as one of the anesthetic agents in this laboratory. Certain differences are apparent when this anesthetic is used in place of ether alone. Searles and Essex[9] have shown that there is a concentration of the hemoglobin and cellular elements of peripheral blood in the dog when anesthetized with ether. They also demonstrated that there is a diminution in the amount of hemoglobin and cellular elements per unit volume of peripheral blood when dogs are anesthetized with sodium amytal. The spleen has been shown to be largely responsible for this alteration in the concentration of erythrocytes. As is well known, dogs under ether anesthesia salivate profusely; however, under sodium amytal anesthesia, salivation is much less marked or is absent. Because of the marked difference in the action of these anesthetics it was decided to determine by a series of experiments whether the onset of traumatic shock would be the same under each of them.

PROCEDURE.—As has been pointed out by various investigators, it is desirable to standardize the methods of producing shock if studies carried out on its mechanism, prevention, or treatment are to have significance. For this reason, in planning a number of experiments associated with the condition of traumatic shock, our first step was to develop a standard method of producing trauma. In order to test the effect of different anesthetic agents it was necessary to use the same species of animal and to use the same method in producing trauma. All experiments were done on dogs. Shock was produced by manipulation and exposure of the intestines. A series of experiments was done under ether anesthesia alone, sodium amytal anesthesia alone, and with ether and sodium amytal anesthesia combined.

All animals were fasted for 24 hours before use. A control sample of 1 cc. of blood was withdrawn from the saphenous vein, care being taken to prevent the animals from becoming unduly excited. They were then anesthetized and, 30 minutes later, a second sample of blood was taken. The abdomen was then opened, precautions being taken to reduce loss of blood to a minimum. The entire length of small intestine was delivered outside the abdominal cavity and gently manipulated by a continuous rolling motion between the hands of the operator. After 30 minutes of manipulation the

intestines were spread out on towels on the anterior abdominal wall. The intestines were turned every 30 minutes to remove fibrin and to avoid unequal exposure of the loops. The blood pressure in the femoral artery was recorded at intervals on a standard kymograph. When the blood pressure had declined to a level of 70 Mm. of mercury, the animals were considered to be in a state of shock. When the blood pressure had remained at this level for a few minutes, a third sample of blood was withdrawn from a vein in the leg.

Samples of blood were tested for cell volume by the standard hematocrit method and for hemoglobin content with the Sheard-Sanford photoelectric apparatus. In some animals changes in rectal temperature were recorded.

A series of animals was tested under the following combinations of anesthetics: One series was given ether alone; another sodium amytal alone, 50 mg. for each kilogram of body weight, while others were given 10 or 25 mg. of sodium amytal per kilogram of body weight either prior to or following the administration of ether.

Ether anesthesia was accomplished by placing the animals in a cabinet containing warmed ether vapor.[4] After the animals were relaxed, an intratracheal tube was inserted.[3] The intratracheal tube was connected to an auto-inhalation ether apparatus.[3] A level of anesthesia was maintained which diminished but did not completely abolish the eyelid reflex. Sodium amytal anesthesia was administered by the intravenous injection of a freshly prepared 5 per cent solution of sodium amytal in distilled water. With amounts of 50 mg. for each kilogram of body weight, deep anesthesia was accomplished. When 25 mg. for each kilogram of body weight was administered, most of the animals were ataxic but were able to walk to the ether cabinet for the administration of ether. Occasionally this amount was sufficient to produce light anesthesia.

In order to obviate as much as possible any personal factor in the evaluation of results, one of us administered the anesthetics, and the others were unaware of the type of anesthesia employed until after the different series of experiments were completed.

RESULTS.—*Ether Anesthesia Only.*—Manipulation of the intestines was carried out under ether anesthesia alone with seven animals. The average time of the onset of shock was three hours and 53 minutes after the beginning of intestinal manipulation. The average time of death in this series was five hours and 53 minutes. After 30 minutes of ether anesthesia, before the abdomen was opened, the average concentration of hemoglobin was 120.2 per cent as compared with the control determinations of 100 per cent. After shock developed, the average concentration of hemoglobin was 130.3 per cent. The rectal temperature in this group under ether anesthesia averaged 39.1° C.; this declined to 36.5° C. at the time of shock and registered 34.5° C. just prior to death.

*Sodium Amytal Anesthesia Only.*—In a series of three animals under sodium amytal anesthesia alone (50 mg. per kilogram body weight) the

average time of the onset of shock was 11 hours and 33 minutes after the beginning of intestinal manipulation. The average time of death was 14 hours and 44 minutes. After 30 minutes of sodium amytal anesthesia, the average concentration of hemoglobin was 87.8 per cent of normal control samples. At the time of shock the average concentration of hemoglobin was 137.7 per cent. The average rectal temperature under sodium amytal anesthesia was 38.6° C.; this declined to 35.5° C. at the time of shock and registered 33.5° C. just prior to death.

*Combined Ether and Sodium Amytal Anesthesia.*—Five animals were tested as follows: After the administration of 25 mg. of sodium amytal for each kilogram of body weight a period of 15 minutes was allowed to elapse. The animals were then etherized. After 15 minutes of ether administration the usual manipulation of the intestines was carried out. The average time of the onset of shock in this series was ten hours and 31 minutes. The average time of death was 13 hours and 31 minutes. The concentration of hemoglobin after 15 minutes of sodium amytal anesthesia averaged 86.3 per cent of control samples. Fifteen minutes after the addition of ether the average concentration of hemoglobin was 105.7 per cent. At the time of shock the average concentration of hemoglobin was 136.2 per cent.

Two animals were tested in which 25 mg. of sodium amytal per kilogram of body weight was given after 15 minutes of ether anesthesia. Under this anesthesia shock developed in one animal six hours and 25 minutes after the beginning of intestinal manipulation and the dog died after ten hours and 15 minutes. Shock developed in the other dog 11 hours and 25 minutes after the beginning of intestinal manipulation and it died after 15 hours and five minutes. In these animals the concentration of hemoglobin was 119 per cent of normal control samples after 15 minutes of ether anesthesia. Fifteen minutes after the administration of sodium amytal the concentration was 114 per cent, indicating that after the concentration had occurred under ether anesthesia, sodium amytal was not effective in lowering this concentration as greatly as when sodium amytal was used alone.

Two animals were tested in which only 10 mg. of sodium amytal per kilogram of body weight was administered 15 minutes prior to the administration of ether. Shock developed in one case in three hours and ten minutes and the animal died four hours and 55 minutes after the beginning of intestinal manipulation. Because the first animal reacted in a manner similar to those under ether anesthesia only, and the other reacted in a manner similar to those under sodium amytal anesthesia only, it was decided to confine the major portion of this study to the larger doses of sodium amytal. However, our data indicate that the minimal dose of sodium amytal necessary to prolong the onset of traumatic shock induced by intestinal manipulation is between 10 and 25 mg. per kilogram of body weight.

The time of the onset of shock and the time of death for the foregoing series of animals is represented in a bar diagram (Chart 1). Changes in the concentration of hemoglobin in these series are recorded in Chart 2.

*Comment.*—Reports by various workers on the problem of traumatic shock have indicated little difference in the results following trauma to the limb under different anesthetic agents. Parsons and Phemister,[6] working with dogs, used ether alone, ether and morphine, barbital alone, and barbital and morphine. When morphine was used in combination with the other

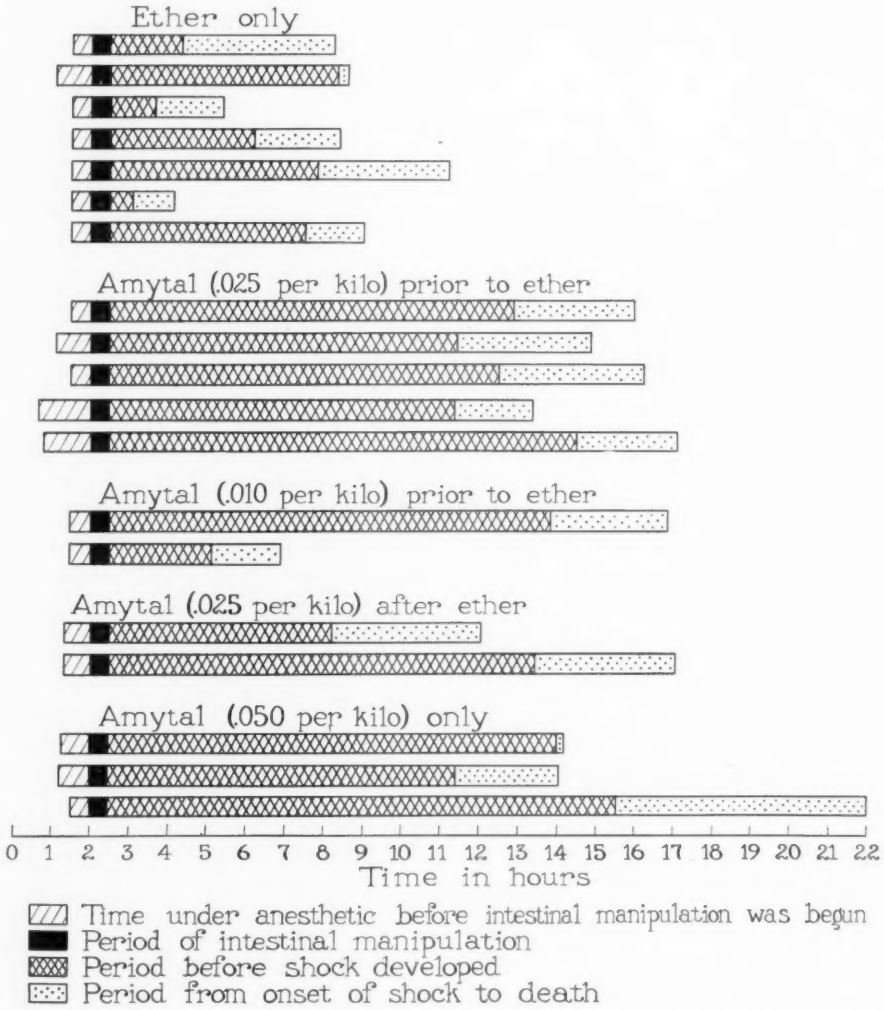
Ether only
Amytal (.025 per kilo) prior to ether
Amytal (.010 per kilo) prior to ether
Amytal (.025 per kilo) after ether
Amytal (.050 per kilo) only
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Time in hours
Time under anesthetic before intestinal manipulation was begun
Period of intestinal manipulation
Period before shock developed
Period from onset of shock to death

CHART 1.—Graphic representation of the data on each series of experiments with ether or amytal alone or combinations of these anesthetics.

agents just mentioned, they noted that the blood pressure was slightly lower than when these agents were used alone. Otherwise they noted no significant difference in the time of the onset of shock under these anesthetic agents following standardized trauma to the hind limbs. Roome, Keith and Phemister[7] used sodium barbital anesthesia and ether anesthesia and obtained similar results with these two anesthetics. Marshall,[5] Crile,[2] and Cannon[1] reported

that the blood pressure was much lower under ether or chloroform anesthesia than under nitrous oxide anesthesia.

It is apparent from our findings that when sodium amytal anesthesia is used alone, or when sodium amytal is given preliminary to ether anesthesia in the amount of 25 mg. per kilogram of body weight of the dog, the time of the onset of shock and the time of death is delayed markedly after trauma and exposure of the intestines. The mechanism by which sodium amytal pro-

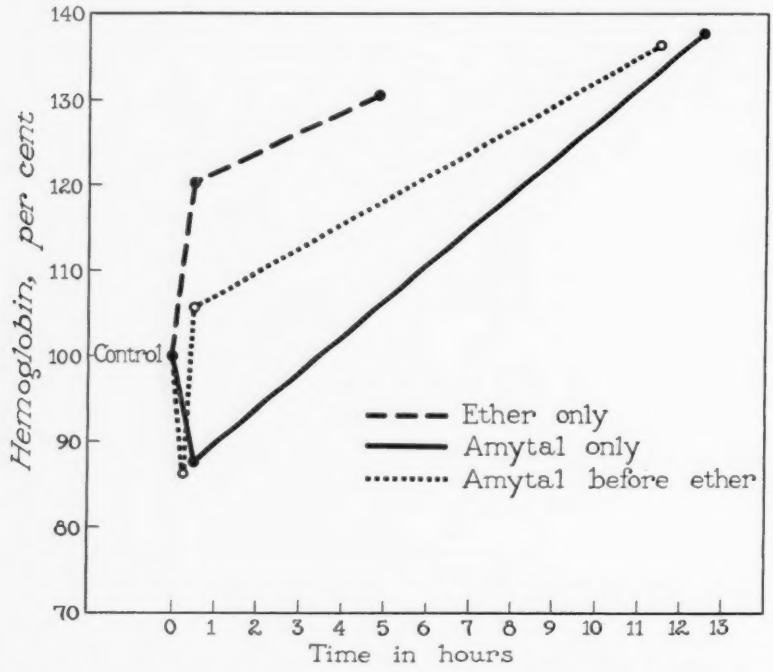


CHART 2.—The average values of hemoglobin obtained in a series of experiments with amytal or ether anesthesia used alone or in combination.

duced such a result is an open question; however, we wish to mention a few observations that may have a bearing on the matter. We have noted that salivation does not occur under sodium amytal anesthesia alone. Those animals receiving preliminary medication with sodium amytal did not salivate. In cases in which ether alone was used, marked salivation occurred, but within an hour after the administration of sodium amytal salivation ceased and the mouth was dry throughout the remainder of the experiment. Prevention of loss of fluid in this way is considered of importance in maintaining the total amount of fluid in the general circulation. Loss of fluid from the surface of the traumatized intestines was much less rapid under sodium amytal than under ether anesthesia. It is our belief that sodium amytal delays this exudation. The amount of fluid lost from the circulation was apparently the

same in all series at the time of shock, as shown by the concentration of hemoglobin at that time. This indicates that sodium amytal probably acts in such a way as to delay the loss of fluid from the circulation following trauma to the intestines, and that thereby the onset of shock is retarded. For this reason we do not consider that this anesthetic agent would necessarily be of value after shock has developed. No explanation is at hand to explain the physiologic mechanism by which sodium amytal delays the loss of fluid following this type of trauma.

After manipulation of the intestine had been carried out for 30 minutes, there was a marked difference in the appearance of the bowel, depending on the anesthesia employed. Under ether anesthesia alone the bowel was slightly cyanotic and the exudation of fluid was sufficient to dampen several layers of cloth spread under the intestinal loops. After the same degree of trauma under sodium amytal anesthesia, alone or in combination with ether, the intestines were pink in color, appearing only moderately inflamed and the exudation of fluid was less rapid.

It is a well known fact that considerable fluid is lost from the body through respiration. The respiratory rate under ether anesthesia alone varies from 30 to 40 per minute. Under sodium amytal anesthesia alone it was from 8 to 14 per minute. In the experiments in which sodium amytal was administered prior to the inhalation of ether, or 15 minutes thereafter, the respiratory rate was from 30 to 40 per minute. Since the loss of fluid through respiration was not measured, a definite statement cannot be made as to the effects of the two anesthetic agents in this regard.

## SUMMARY

Under a standard method of producing traumatic shock in the dog we have found that sodium amytal anesthesia alone, or sodium amytal preliminary to ether anesthesia, results in a definite delay in the onset of shock and of death. Loss of fluid from the circulation in the form of saliva and in the form of exudate from the surface of the traumatized intestine is less rapid when sodium amytal has been administered.

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# MODIFIED DORSAL SYMPATHECTOMY FOR VASCULAR SPASM (RAYNAUD'S DISEASE) OF THE UPPER EXTREMITY*

A PRELIMINARY REPORT

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THE end-results of cervicodorsal sympathetic ganglionectomy for vascular spasm (Raynaud's disease) of the upper extremity have not been satisfactory. The reasons for failure of this type of operation have been discussed in some detail in previous communications.[1, 2] This evidence will be briefly reviewed before presenting a modified dorsal sympathectomy which at the time of writing gives evidence of being a satisfactory solution of the problem.

It is generally agreed that the efferent vasoconstrictor fibers to the upper extremity leave the lateral horn of the dorsal cord, pass out by way of the anterior roots to enter the mixed nerves, then leave the nerves by way of communicating white rami to enter the dorsal sympathetic trunk. They then pass a variable distance along the trunk and form synapses in certain of the ganglia. They then leave these ganglia as postganglionic fibers and pass by way of other communicating gray rami to the cords of the brachial plexus. From here they are distributed to the blood vessels, leaving the mixed nerves a short distance from their endings in the vessel wall. Probably all of the synapses concerned lie in the inferior cervical and the first and second dorsal sympathetic ganglia although there may possibly be a few in the third dorsal ganglion.

In our earlier cases the upper extremity was sympathectomized by removing the second and third dorsal ganglia. The immediate result was excellent, but in the course of six months to a year signs of vascular spasm returned. Along with this was noticed, to a lesser degree, return of perspiration. Other early cases were sympathectomized by removal of the first and second dorsal ganglia. Again the immediate result was excellent but the same evidence of recurrence appeared in the course of six months to a year. Our inclination, at that time, was to explain these delayed recurrences on the basis of regeneration of nerve fibers. Accordingly another group of cases was sympathectomized by a more extensive operation in which the inferior cervical, the first and second dorsal sympathetic ganglia and intervening trunk were excised. Again recurrence of vascular spasm was noted but instead of appearing in six months to a year, in some instances it appeared in about two weeks. This obviously could not be explained on the basis of regeneration of nerve fibers as Horner's syndrome and a complete sudomotor paralysis persisted.

* Presented before the Boston Surgical Society, November 4, 1935.

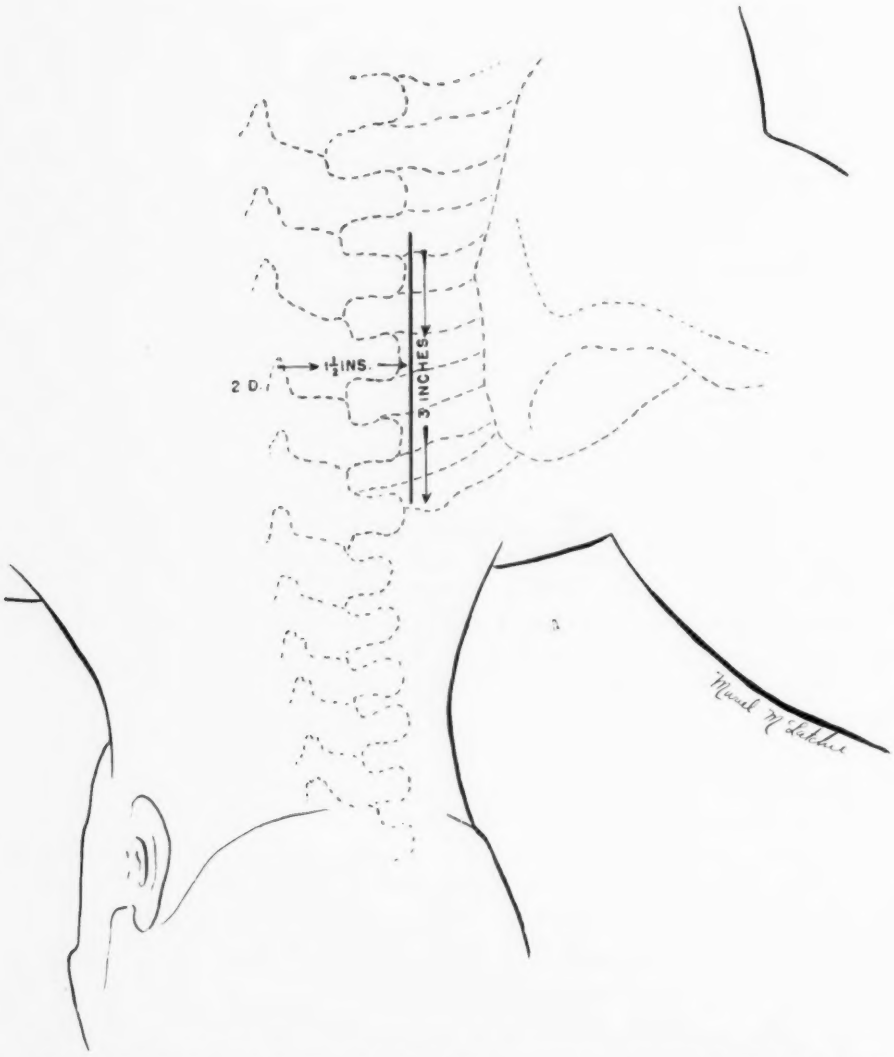
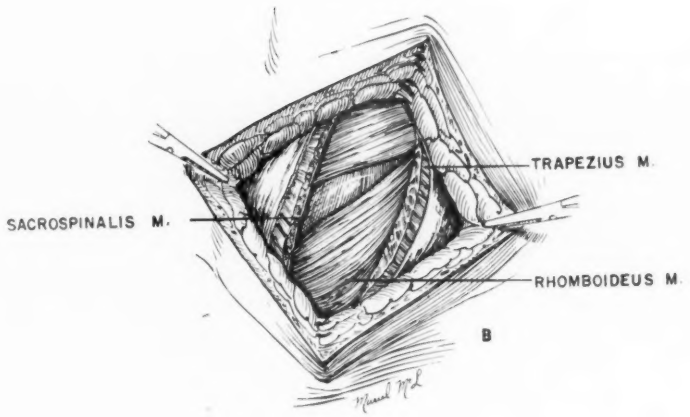
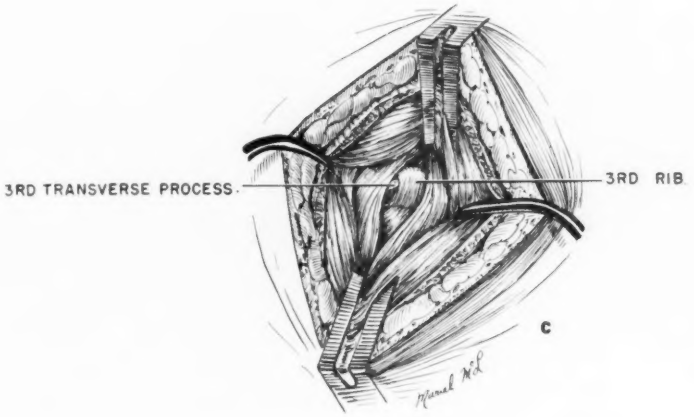



FIG. 1.—Illustrating (A) Position of incision with reference to spine and shoulder girdle. (B) Incision carried down through trapezius muscle exposing rhomboid muscles and sacrospinalis group. (C) Sacrospinalis muscle split vertically over line of transverse process exposing third rib and transverse process. (D) Third rib and transverse process have been resected, the intercostal nerves and sympathetic trunk identified, and lung and pleura dissected back from bodies of vertebrae. Illustrations B, C, and D were drawn from the right of patient's head looking to the left and toward the foot of table.


TRAPEZIUS M.
SACROSPINALIS M.
RHOMBOIDEUS M.
B


3RD TRANSVERSE PROCESS
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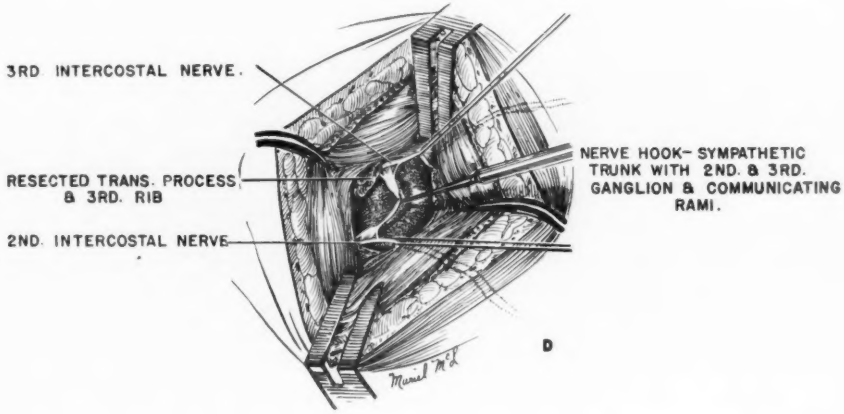
C


3RD INTERCOSTAL NERVE.
RESECTED TRANS. PROCESS & 3RD. RIB
2ND. INTERCOSTAL NERVE
NERVE HOOK- SYMPATHETIC TRUNK WITH 2ND. & 3RD. GANGLION & COMMUNICATING RAMI.
D

Extensive animal and clinical experimental study was then carried on to determine the cause of recurrence of vascular spasm after ganglionectomy.[1, 2] It was found that this type of vascular spasm was due to the action of adrenalin on the vessel wall; that it took between ten days and three weeks for this phenomenon to become well marked after extensive ganglionectomy; and that this spasm could be inhibited in animals by excision of one adrenal gland and denervation of the other. It was also shown in rabbits and in monkeys that the adrenalin sensitivity of smooth muscle in the arteriolar walls was much less increased when the preganglionic vasoconstrictor neu-

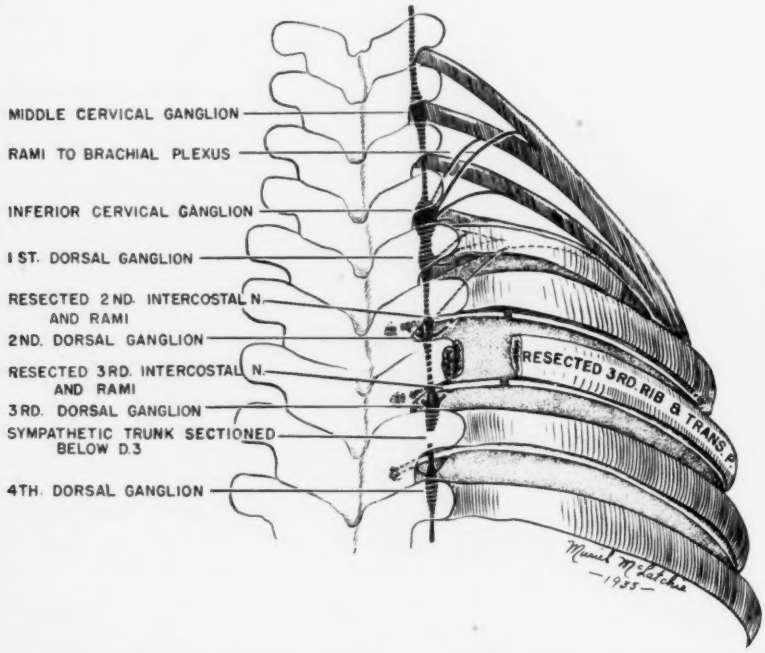

MIDDLE CERVICAL GANGLION
RAMI TO BRACHIAL PLEXUS
INFERIOR CERVICAL GANGLION
1 ST. DORSAL GANGLION
RESECTED 2 ND. INTERCOSTAL N. AND RAMI
2ND. DORSAL GANGLION
RESECTED 3RD. INTERCOSTAL N. AND RAMI
3RD. DORSAL GANGLION
SYMPATHETIC TRUNK SECTIONED BELOW D.3
4TH. DORSAL GANGLION
RESECTED 3RD. RIB & TRANS P.

FIG. 2.—A diagrammatic representation of the operation, showing resected portion of third rib and transverse process, resected second and third intercostal nerves with accompanying rami, and sectioned sympathetic trunk below the third dorsal ganglion. Enough mobility is produced in this way so that the upper end of the sectioned sympathetic trunk can be brought into the incision, and sutured without tension to the muscles of the back. This should help prevent regeneration of nerve fibers.

rons alone were severed.[3] Grant[4] has recently published quite similar conclusions and Hampel[5] has quantitatively measured the contraction of the denervated smooth muscle in the nictitating membrane of the cat when stimulated by adrenalin. His experiments show that smooth muscle denervated by degeneration of the postganglionic fibers is over twice as sensitive to adrenalin as it is after destruction of the preganglionic portion of the sympathetic pathway.

From these facts it seemed apparent that vascular spasm after ganglionectomy was probably due to degeneration of the postganglionic fibers and the consequent extreme sensitivity to adrenalin which is known to occur when this takes place. The cells of origin of the postganglionic neurons lie in the

sympathetic ganglia and the fibers presumably will degenerate if the ganglia connected with the roots of the brachial and lumbosacral plexuses are removed. Lumbar ganglionectomy had always been successful in relieving

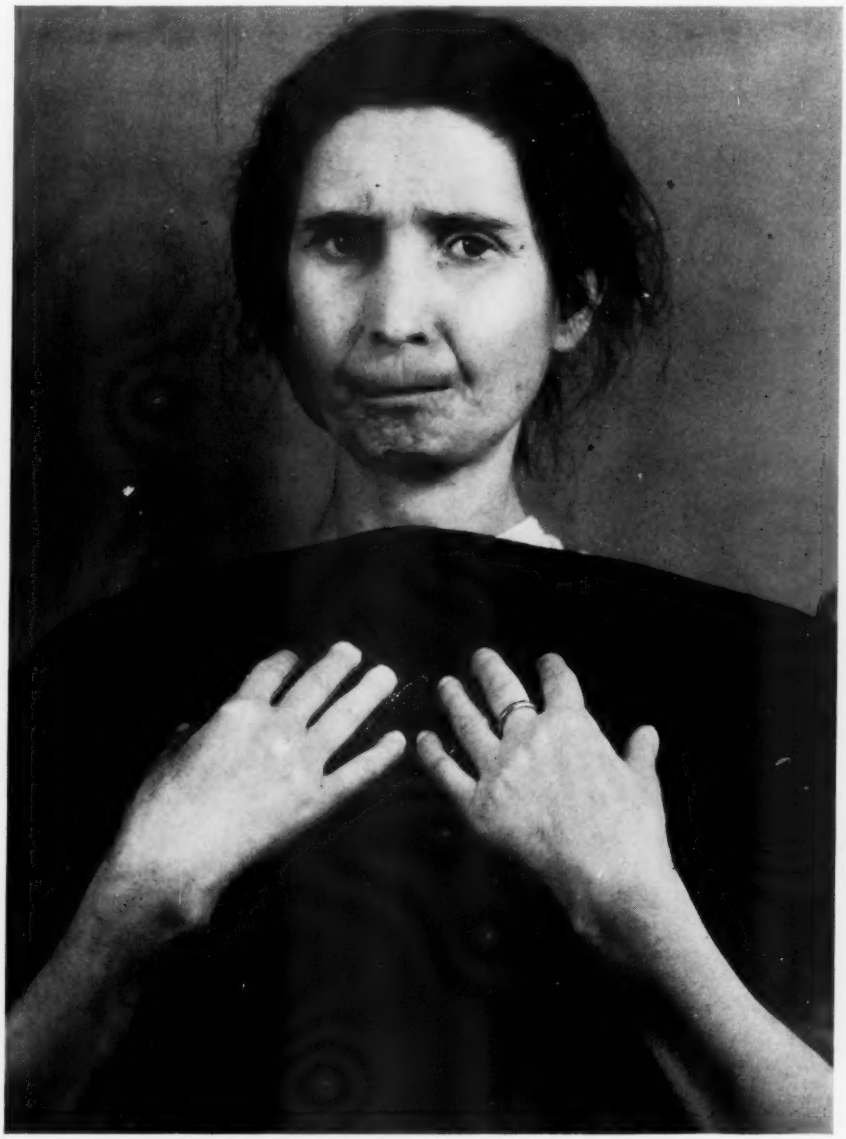


FIG. 3.—(Case 2, Table I.) Showing advanced changes in hands, face and neck due to extensive scleroderma. Note the drawn expression of the face which is characteristic of the late stages of this disease. Also note the shortening of the finger tips due to loss of bone. The skin of the hands is stiff and rigid, causing marked limitation of motion. These changes took place over a period of five years.

vascular spasm in the lower extremities. The above explanation at first seemed contradictory until it was pointed out by Dr. James C. White that the postganglionic neurons to the sciatic nerve probably orignate in the lowest

TABLE I

| Name | Age | Sex | Duration of Symptoms | Evidence of Vascular Spasm | Evidence of Vascular Obliteration | Operation | Interval Since Operation | Result |
|---|---|---|---|---|---|---|---|---|
| 1. Siracusa BM 17064 | 21 | M. | 2 yrs. | Marked blanching, cyanosis, slight moisture, no temperature rise on novocain block | Striking fibrosis of fingers with scleroderma | Left dorsal sympathectomy, resection $D_2$, section of trunk below $D_2$ | 11 mos. | Hand pink, dry; temperature rise about 15° F., occasional slight blanching spells |
| 2. Sclafoni 343387 | 41 | F. | 5 yrs. | Cyanotic hands, 10° F. rise on novocain block | Marked fibrosis; scleroderma hands, neck, face; loss terminal phalanges | Right dorsal sympathectomy | 9 mos. | Hand pink, dry, warm; temperature rise 10°–15° F., slight momentary cyanosis |
| 3. Lazaropolous 346502 | 18 | F. | 8 yrs. | Marked cyanosis, cold moist hands, novocain block not done | Marked fibrosis; scleroderma hands, face, neck | (1) Right dorsal sympathectomy.<br>(2) Left dorsal sympathectomy | 6 mos.<br>3 mos. | Hands pink, dry; temperature rise about 10° F., occasional momentary color change |
| 4. Ganno 330674 | 37 | F. | 8 yrs. | Marked cyanosis, moisture, hands | Extensive fibrosis; scleroderma face, neck, hands; loss many terminal phalanges | Right dorsal sympathectomy | 4 mos. | Hand pink, dry; 5°–10° F. warmer, does not change color, improvement in scleroderma hand, right side face, neck |
| 5. Gilbert BM 16374 | 45 | F. | 15 yrs. | Marked cyanosis, no temperature rise on novocain block | Striking fibrosis; scleroderma hands, neck, face; destruction terminal phalanges by roentgen ray, ulceration several fingertips | Left dorsal sympathectomy, resection $D_2$, section of trunk below $D_3$ | 4 mos. | Hand pink, dry, without color change; slight temperature elevation—2°–3° F. fingertips, about 5° F. in palm |
| 6. Walsh 348518 | 23 | F. | 1 yr. | Marked blanching, cyanosis, moisture, temperature rise | Slight scleroderma, ulcers several fingertips, rheumatoid | (1) Right dorsal sympathectomy.<br>(2) Left dorsal | 4 mos.<br>4 mos. | Hands pink, dry, warm, no color change, surface tem- |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 10° F. on novocain block | arthritis | sympathectomy | | perature rise about 15° F. |
| 7. | Bird PH 16356 | 24 | F. | 2 yrs. | Marked cyanosis, moisture, striking temperature rise about 20° F. on novocain block | None | (1) Bilateral lumbar ganglionectomy. 10 mos.<br>(2) Right dorsal sympathectomy 4 mos. | Feet warm, dry, pink, no color change; hand warm, dry, pink, no color change; temperature rise 20° F. all 3 extremities |
| 8. | Bushway BM 12662 | 33 | F. | 1½ yrs. | Marked cyanosis, moisture, slight temperature rise—less than 5° F. on novocain block | Marked fibrosis; scleroderma face, neck, hands | (1) Right dorsal sympathectomy 9 mos.<br>(2) Left dorsal sympathectomy 3 mos. | Hands dry, warm, pink; occasional momentary cyanosis, striking improvement in scleroderma |
| 9. | Schneider 308408 | 24 | F. | 10 yrs. | Marked cyanosis, moisture, surface temperature rise about 20° F. on on novocain block | None | (1) Bilateral lumbar ganglionectomy 10 mos.<br>(2) Right dorsal sympathectomy. 2 mos.<br>(3) Left dorsal sympathectomy | Feet, left hand warm, dry, pink, no color change; temperature rise about 20° F.* |
| 10. | Coté 349991 | 18 | M. | 4 yrs. | Marked blanching, moisture, surface temperature rise about 20° F. on novocain block, ulcer tip of right fifth finger | Slight if any | (1) Right dorsal sympathectomy. 2 wks.<br>(2) Left dorsal sympathectomy 1 wk. | Both hands warm, dry, pink, no color change; temperature rise about 20° F. |
| 11. | Roud 349860 | 41 | F. | 3½ yrs. | Marked cyanosis, moisture, temperature rise 5°–10° F. on novocain block | Marked scleroderma, calcification of subcutaneous tissues | Left dorsal sympathectomy 1 wk. | Hand pink, dry, no color change; 10° F. warmer |

* In Case 9 the right hand is slightly moist and is distinctly cooler than the left. It is not sensitive to adrenalin, however (Graph 2). This is apparently due to an incomplete sympathectomy. It has not been determined as yet which fibers were not interrupted. This should be classified as a technical error, rather than sensitivity to adrenalin or regeneration of nerve fibers.

Eight of these cases showed advanced obliterative changes as well as spasm. Cases 7, 9 and 10 were the only early cases in the group showing little evidence of vascular occlusion. These obliterative changes may take place within two years, while in other instances a similar degree of occlusion may not appear for many years.

lumbar and the sacral sympathetic ganglia. Consequently when the second and third lumbar ganglia are removed—the usual operation to sympathectomize the lower extremity—we are probably cutting largely preganglionic fibers to the lower extremity. From experimental evidence given in the preceding paragraph this should result in a far lesser sensitization of the foot to circulating hormones.

Based upon the foregoing facts and theories a modified dorsal sympathectomy has been employed in a small group of cases having vascular spasm of the upper extremities. The technic (Fig. 1) consists of a vertical

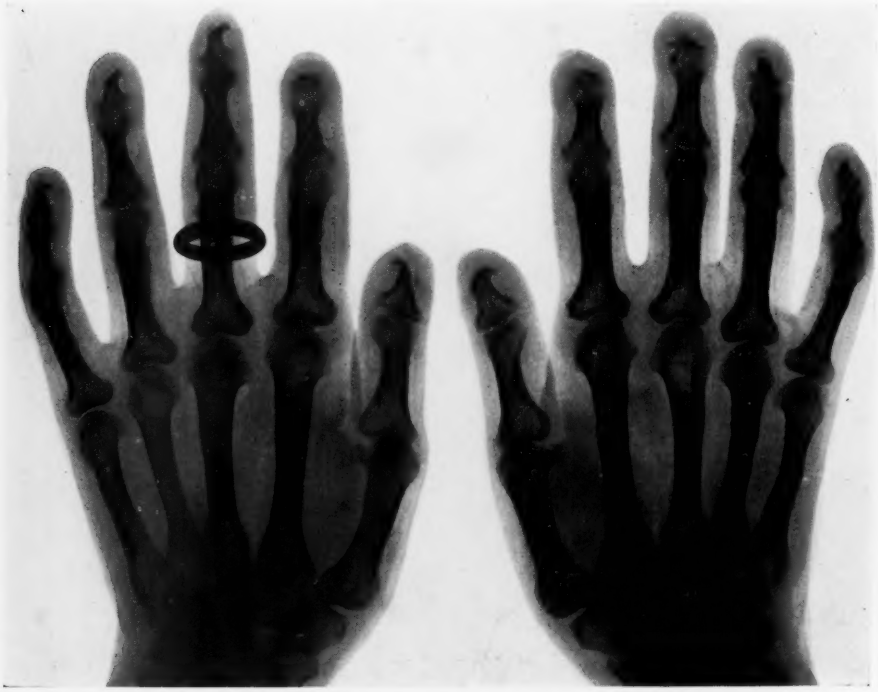


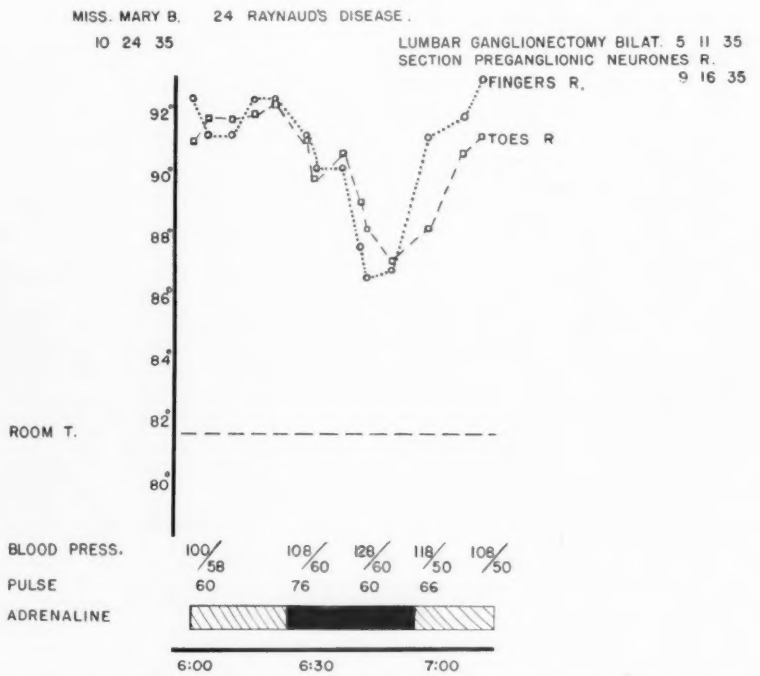
FIG. 4.—(Case 2, Table I.) Roentgenogram showing destruction of terminal phalanges of several fingers of each hand. This results in short blunt finger tips, and is characteristic of the end-result of prolonged vascular spasm. Often calcium deposits can be seen in the soft tissues. This has not occurred in this case, but is another typical change often seen.

paramedian incision about 6 cm. long, 3 cm. from the midline, centering the incision opposite the second dorsal spinous process. The inner inch of the third rib and corresponding transverse process are resected. The inner inch and one-half of the second and third intercostal nerves are resected from the intervertebral foramen outward (Fig. 2). The dorsal sympathetic trunk is identified between the second and third dorsal ganglia, is sectioned just below the third dorsal ganglion, and the upper end of the sectioned trunk is brought out of the thorax and sutured without tension to the muscles of the back.

The intercostal nerves are resected in order to guarantee a complete ramisectomy and also as an additional safeguard against regeneration. This

results in a zone of anesthesia about the thorax which becomes so narrow in a few months that it is a matter of no importance. The axillary region remains quite anesthetic and perspiration is inhibited. In two cases there has been a slight variation in the surgical technic. In both, only the second intercostal nerve was resected. In one of these the sympathetic trunk was also sectioned below the second dorsal ganglion and in the other below the third dorsal ganglion. The immediate results are satisfactory in each instance although it is felt that resection of both the second and third intercostal nerves and section of the sympathetic trunk below the third dorsal ganglion is theoretically a better procedure.*

By this operation all possible sympathetic connections between the dorsal




GRAPH 1.—(Case 7, Table I.) Showing the same temperature fall in the sympathectomized hand and foot in response to intravenous adrenalin (1 to 250,000). A fall of about 6° F. is recorded. There is no clinical evidence of sensitivity to adrenalin in either extremity. This is the usual finding in an extremity which has been sympathectomized by section of preganglionic fibers. If postganglionic fibers were sectioned in this case, a temperature drop of about 15° F. would be expected under similar conditions.

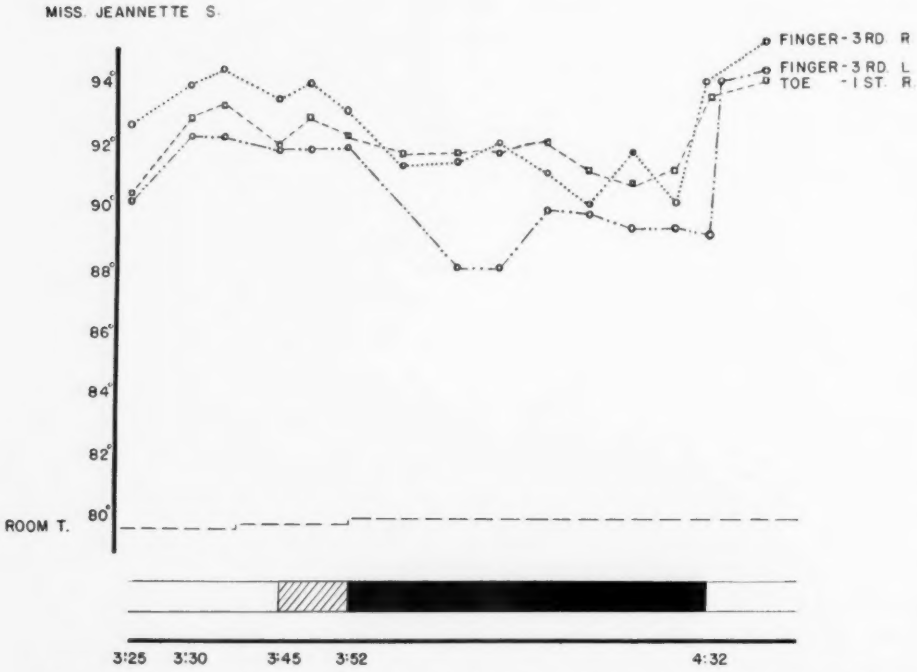
cord and the brachial plexus are severed except those which might be contained in the first dorsal nerve. This of course cannot be divided as motor and sensory paralysis in the arm would result. We believe that only preganglionic fibers are divided in this operation and that the postganglionic fibers to the arm are left intact.

The clinical results to date would indicate that few if any efferent sympathetic fibers to the hand pass over the first dorsal nerve. Further corroboration of this is found in unpublished experimental work by Dr. James C.

* See last paragraph in article for slight change in technique of operation.

White, who has found that it is necessary to divide the dorsal anterior roots as low as the eleventh or twelfth in order to completely sympathectomize the upper extremity of a monkey, while the upper two or three roots seem of little importance. It would seem probable that in the human, efferent sympathetic impulses to the upper extremity arise from nearly the entire dorsal cord, the first segment carrying few if any pathways.

To date, December, 1935, 16 upper extremities have been sympathectomized in 11 patients (Table 1). Eight of the cases were well advanced in the disease with associated scleroderma (Fig. 3), fibrosis of the soft tissues of the fingers, and often with destruction of the terminal phalanges (Fig. 4). In some instances no preoperative surface temperature rise could be obtained




GRAPH 2.—(Case 9, Table I.) Intravenous administration of adrenalin (1 to 250,000) is given at the rate of about 60 drops per minute. This is shown by the solid black rectangle in the diagram. A preliminary period of intravenous saline at the same rate is shown by the cross-hatched rectangle. All three extremities show only a very slight temperature fall during the experiment. The left hand shows the greatest temperature drop (4° F.), while the right hand and foot show little change. The left hand and right foot are completely sympathectomized. The right hand is incompletely sympathectomized.

by novocain block. All have shown a surface temperature rise after operation, this elevation ranging between 5° and 20° F. at the tips of the fingers. The temperature rise is dependent upon the amount of organic occlusion already present. In all but one instance (footnote, Table I) the hands appear to be very completely sympathectomized, being pink in color and dry. In some cases momentary discoloration of the fingers has appeared at times after operation, but this has not been of any practical importance. Two cases with associated scleroderma and pigmentation of the skin of the

neck, face and forehead have shown a striking decrease in the pigmentation on the operated side in the course of four to six months, with softening and increased pliability of the skin. Perspiration is abolished over the head, face and neck as well as the axilla and extremity. A Horner's sign is not produced by this operation as was the case when the inferior cervical or first dorsal ganglion was removed.

The first operation in this series was done January 24, 1935, 11 months ago. By this time recurrence of vascular spasm would usually be clinically obvious following the operation of ganglionectomy. It is a little early to conclude that recurrence of vascular spasm could not take place at a later date due to regeneration of nerve fibers.

Three cases have been tested by the intravenous administration of adrenalin in a dilution of 1 to 250,000. The surface temperature fall is comparable to that obtained in a sympathectomized foot. Two of these cases (Graphs 1 and 2) also have had both feet sympathectomized and the temperature fall in the sympathectomized hands and feet is almost identical.

From a clinical point of view this modified type of sympathectomy is not followed by recurrence of vascular spasm due to the action of adrenalin on the blood vessels in the sympathectomized area. This was the greatest drawback to the operation of cervicodorsal ganglionectomy and rendered that operation unsatisfactory in our opinion.

Since writing this paper my attention has been called to a similar operation reported by Telford.[6] He uses an anterior approach, dividing the white rami between the second and third intercostal nerves and the corresponding sympathetic ganglia, and sections the sympathetic trunk below the third dorsal ganglion.

At the present time (Aug. 1, 1936) the series has increased to 33 upper extremities in 23 patients. Several further instances of incomplete sympathectomy have been encountered as described in Table I, Case 9, and Graph 2. The most likely explanation is failure to interrupt all of the rami running from the second and third intercostal nerves to the sympathetic trunk. Failure to section the trunk itself would also produce the same result, but seems a less likely probability. For this reason the technique of operation has been altered so that the dissection of the intercostal nerves is carried into the intervertebral foramen, dividing the dural attachments, and sectioning the anterior and posterior roots as well. In this way it is impossible to overlook any white rami which might arise close to the intervertebral foramen. In the more recent cases, this technique has been followed with uniformly satisfactory results.

## CONCLUSIONS

(1) A modified dorsal sympathectomy for relief of vascular spasm of the upper extremity is described.

(2) We believe that only preganglionic fibers are sectioned in this operation and that the postganglionic fibers are left intact.

(3) No clinical evidence of recurrence of vascular spasm has been noted. The longest interval since operation is 11 months.

(4) The surface temperature fall in the hand in response to intravenous administration of adrenalin in a dilution of 1 to 250,000 is comparable to that observed in the foot after lumbar ganglionectomy.

(5) If recurrence of vascular spasm does not take place at a later date due to regeneration of nerve fibers this should be a satisfactory method of eliminating vascular spasm in the upper extremity.

(6) It seems only reasonable to predict that the best results will be obtained when operation is done before advanced fibrosis with the associated vascular occlusion takes place.

(7) The cause of recurrence of vascular spasm after cervicodorsal ganglionectomy is reviewed.

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# RESECTION OF THE PRESACRAL NERVE FOR DYSMENORRHEA AND PELVIC PAIN

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DES MOINES, IOWA

THE present report is a review of eight cases of dysmenorrhea relieved by section of the presacral nerve.

*Historic Survey.*—Jaboulay[17] made the first attempt to relieve pelvic pain by dividing the pelvic sympathetic fibers through a retrorectal approach. A year later, Ruggi[26, 27] added to this investigation by advocating resection of the utero-ovarian plexus via a transperitoneal route. The results of these operations met with partial success, but little more was achieved until Leriche[22, 23] introduced peri-arterial sympathectomy of the internal iliac artery as a means of relieving pain in cases of functional dysmenorrhea. The latter procedure was utilized by Cotté[6, 7] and Michon.[24] In 1925, Cotté introduced the operation of resection of the superior hypogastric plexus, called the presacral nerve of Latarjet and Bonnet,[20] for functional dysmenorrhea and reported favorable results. He listed six indications for the use of his method: (1) pelvic neuralgia, (2) vaginismus, (3) dysmenorrhea, resistant to ordinary methods adopted for its relief, (4) hypoplasia of the uterus, accompanied by insufficient and painful menstruation, (5) metrorrhagia of ovarian origin, and (6) sexual neuroses, such as masturbation, nymphomania, *etc.*

Herman[14] is said to have been the first American surgeon to have performed this operation. Then a widespread application of this method was reported by many European surgeons. The same surgical procedure of resection of the presacral nerve has been employed by Learmonth and Braasch[21] for cord, bladder, and certain painful vesical conditions. In 1933, Abbott and Pfaff[2] reported a case of bladder dysfunction and dysmenorrhea which responded to this operation. Since then Adson and Masson,[4] Greenhill and Schmitz,[13] Counseller and Craig,[8] Abbott[1, 3] White,[29] Wetherell,[28] DeCourcy,[9] and Keene[18] have recorded favorable results in cases of pelvic pain.

*Anatomy and Physiology.*—The inferior mesenteric plexus gives rise to the right and left mesenteric nerves which unite below the origin of the inferior mesenteric artery to form the presacral nerve (superior hypogastric plexus). The branches from the left side pass obliquely downward, while the branches from the right side pass posterior to the artery. There are many fine anastomoses between these nerves so that a true plexus is formed which is situated anterior to the bifurcation of the aorta and is separated from it by a thin layer of fascia. The plexus then follows the course of the sacrum into the pelvis. The parietal peritoneum and a thin layer of loose connective tissue lies anterior to the plexus. The root of the mesentery of the sigmoid colon is situated to the left. There are many variations of the superior hypogastric plexus but none of great importance. Latarjet and Bonnet gave it

the name of "presacral nerve." In about 20 per cent of the cases, the fibers join to form a new nerve, and in 80 per cent, the nerves are more or less spread out in plexus formation (Delmas and Laux[10]).

A few filaments from the superior hypogastric plexus course along the common iliac artery. The plexus itself continues down over the promontory of the sacrum and, at the level of the first sacral vertebra, divides into two distinct nerves; the inferior hypogastric nerves. These nerves course downward into the lateral rectal space and terminate in a mass of nerve fibers and ganglion cells named the hypogastric ganglion, which is situated on the superior pelvic space between the peritoneum and the fascia covering the levator ani muscles. This plexus forms again on the anterior surface of the rectum, just posterior to the uterus and vagina, and becomes intimately connected with the uterosacral ligaments.

The nerve supply of the ovary is derived chiefly from the ovarian plexus which arises from the aortic and renal plexuses and follows the course of the ovarian artery. Hovelacque[16] states that three fibers arise from the middle of the renal plexus to join the ovarian plexus. Other nerve bundles may be traced directly to the ovarian ganglion which is situated near the origin of the ovarian artery. There are also rami which connect with the celiac and superior mesenteric ganglia. The ovarian plexus enters the suspensory ligament of the ovary and invests both the ovarian artery and vein. These fibers divide into branches supplying the fallopian tube and broad ligament, the hilus of the ovary and the lateral surface of the uterus. Kuntz[19] states that the afferent fibers supplying the ovary are components of the tenth thoracic nerve.

The fallopian tube receives fibers from the uterine plexus, in addition to branches of the ovarian plexus. The afferent fibers supplying the fallopian tube, according to Kuntz, reach the spinal cord through the eleventh and twelfth thoracic and first lumbar nerves.

The nerve supply of the uterus includes both sympathetic and parasympathetic components. Fontaine and Herrmann[11] state that the nerve fibers in the wall of the uterus are derived from the great plexus of Frankenhäuser,[12] which is situated on each side of the body of the uterus and broad ligament. This plexus receives fibers from the hypogastric plexus, the lower lumbar and sacral sympathetic trunk and the second, third and fourth sacral nerves. There is no evidence to support the view that nerve fibers terminate in the uterine mucosa, as held by older investigators.

Cleland[5] has demonstrated, by the use of paravertebral anesthesia, that the afferent fibers supplying the uterus enter the spinal cord solely through the roots of the eleventh and twelfth thoracic nerves.

In spite of the abundant nerve supply to the ovary, there is no conclusive evidence of a direct functional innervation either of the ovarian follicles or the interstitial tissue. Undoubtedly there are vasomotor changes in the ovary as a result of this complex nerve supply and yet Hinsey and Markee[15] have

reported ovulation induced by the injection of pregnancy urine in rabbits in the complete absence of functional nerve fibers to the ovary.

Kuntz states that the sympathetic nerves supplying the uterus and fallopian tubes exert a motor influence and the parasympathetic nerves an inhibitory influence. However, certain experimental work has caused conflicting opinions to be held as there is evidence of uterine contractions occurring in the absence of nerve stimulations. Stimulation of the hypogastric nerves exerts a motor effect on the uterus and fallopian tubes, but the effect may be very slight. It is also conceded that afferent fibers from the uterus and fallopian tubes are carried through the hypogastric plexus. Thus the removal of the presacral fibers will relieve pain, but Adson and Masson feel that interruption of efferent fibers in the presacral group also produces a dilatation of the blood vessels in the genitalia and musculature of the uterus. This operation has had no deleterious effect upon subsequent pregnancy or the normal menstrual cycle and the functions of the bowel and bladder have not been impaired.

*Mechanism of Dysmenorrhea.*—Counseller and Craig have described two types of dysmenorrhea: primary and secondary. The primary dysmenorrhea is not dependent upon pathologic change in the pelvis and many theories have been advanced regarding the cause of this painful phenomenon. The theory of retention of menstrual blood as a result of uterine displacement cannot be accepted readily because the cervix can be dilated with ease and Novak[25] has reported that the rate of discharge of menstrual blood of the normal woman averages about two-thirds of a drop per minute. This small amount of blood could hardly be retained by uterine displacement. The hypothesis of hypoplasia of the uterus causing pain as a result of faulty muscular development failing to respond to menstrual stimulation is not feasible because the majority of women have a uterus which is normal in size. There have not been sufficiently controlled reports to consider the endocrine system as a definite factor in the production of dysmenorrhea. It is also known that marriage and subsequent pregnancy will abolish certain types of dysmenorrhea; in addition, the psychic element must be borne in mind. However, there are certain cases in which menstrual pain is so severe that it resists any therapeutic agent and in this type of case resection of the presacral nerve is indicated.

The secondary dysmenorrhea is the result of demonstrable pathologic change in the pelvis, such as: uterine myoma, endometriosis, salpingitis, ovarian tumors and marked uterine displacement. It is obvious that correction of these known pathologic processes is indicated in preference to section of the presacral nerve. At times, the recognized pathologic process seems insufficient to cause such severe pain and, in these patients, presacral neurectomy may be utilized as an adjunct in the correction of severe dysmenorrhea.

Fontaine and Herrmann have described three types of cases in which resection of the presacral nerve afforded relief from pain in 22 of 28 cases.

(1) Where slight pathologic processes in the pelvis do not respond to ordinary gynecologic treatments. These periodic paroxysms of pain were described by Cotté as pelvic plexalgia. The distress begins in the region of

the uterus and radiates to the anus, coccyx and urinary bladder; pain may also radiate to the back and thighs.

(2) Where pain persists after correction of retroversion of the uterus or the removal of a sclerocystic ovary.

(3) Where the pathologic lesion is known but which has been found to be too extensive for surgical removal; inoperable neoplasms causing severe pain.

This report deals with types 1 and 2, or those cases relating to menstrual pain associated with little or no demonstrable pathologic process.

*Operative Technic.*—A low midline incision is made in the abdomen and the patient is placed in the Trendelenberg position. The intestines are packed away and a vertical incision is made in the posterior peritoneum from a point

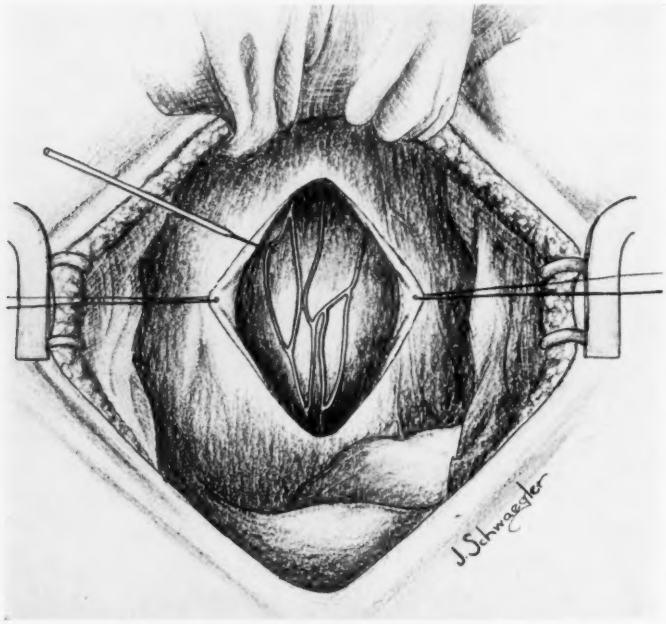


FIG. 1.—Illustrates incision in the posterior peritoneum with the edges retracted. The nerve fibers are picked up with a hook.

3 cm. above the bifurcation of the aorta to 6 cm. below it. The peritoneum is retracted with silk ligatures so that the superior hemorrhoidal artery is drawn out of the way on the left side. In a thin patient the nerves can be seen in a delicate plexus of pelvic lymphatics and loose connective tissue. The use of cotton pledgets will facilitate the dissection in the hollow of the sacrum, between the two common iliac arteries. Precautions must be taken not to injure the left common iliac vein, which lies on the medial side of the artery. Just beneath the aortic bifurcation the strands of the presacral nerve can be identified and picked up on a nerve hook. The application of silver clips will prevent troublesome oozing from the vasa nervorum. The dissection is then carried down over a distance of 6 cm. so that the hollow of the sacrum is denuded. The application of silver clips at the end of the pedicle will prevent

the seepage of lymph. The posterior peritoneum is sutured with fine catgut and the abdominal wall is closed in the usual manner.

## CASE REPORTS

**Case 1.**—An unmarried woman, aged 20, complained of an inability to void or defecate unless massive doses of castor oil were taken. The bladder and bowel would empty every four days and this was accompanied by severe pain. This condition had persisted for two years and was also associated with a severe dysmenorrhea. The past history was negative except that the menses did not appear until she was eighteen and that for two years she suffered from blanching, discoloration and pain in both feet when exposed to the cold or emotional stress. Examinations were negative except for an atonic bladder and colon and the presence of Raynaud's disease of the lower extremi-

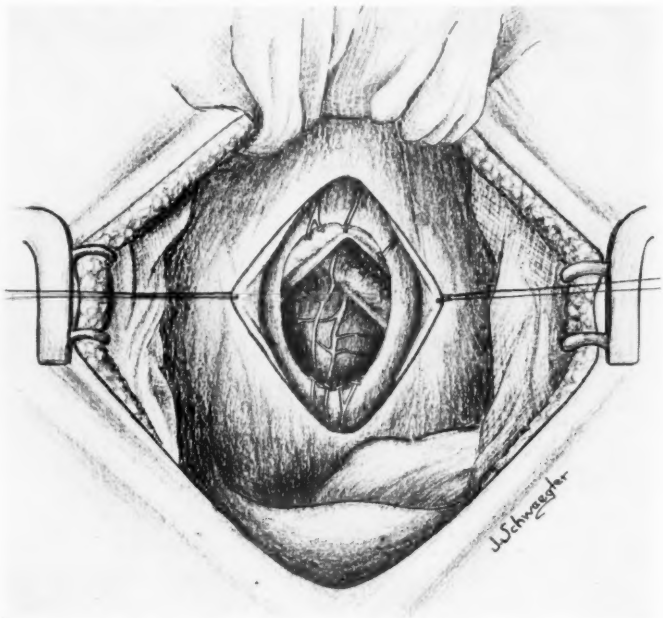


FIG. 2.—Operation completed revealing median sacral and iliac vessels above the promontory of the sacrum. Note silver clips on severed nerve fibers.

ties. The patient was not considered to be suffering from hysteria and the presence of Raynaud's disease seemed to indicate an imbalance of the autonomic nerves.

A laparotomy was performed October 21, 1932, under ether anesthesia and the presacral nerve was resected. In addition, a bilateral lumbar sympathetic ganglionectomy was carried out. Immediately after operation, the lower extremities were warm, dry and pink. Four hours afterwards, the patient voided 150 cc. of urine without difficulty. It was necessary to administer enemata for seven days before a bowel movement occurred with the aid of mineral oil. However, the patient was able to void three and four times daily after the operation. On the fifth postoperative day, the menses appeared without distress. Since her discharge from the hospital, the patient has been able to void three or four times daily, and there has been a daily bowel movement. The feet have remained warm and pink and menstruation has been painless.

This case is illustrative of a general imbalance of the autonomic nervous system as no demonstrable pelvic pathologic process was found.

**Case 2.**—An unmarried woman, aged 20, had suffered from severe dysmenorrhea for years. Roentgen therapy and curettage had failed to afford relief. Examination was negative except for some tenderness over the sacro-iliac region. Roentgenograms revealed a developmental defect of the coccyx, but this was not considered to be an important factor. There was also a leukorrhea. On June 5, 1933, under ether anesthesia, a curettement was performed by Dr. B. C. Barnes and a small amount of reddish deciduous material was removed. A laparotomy was performed and the right ovary,

TABLE I

SUMMARY OF EIGHT CASES OF PRESACRAL NERVE RESECTION

| Age of Patient | Type of Distress | Demonstrable Pathologic Change in Pelvis | Date of Operation | Results |
|---|---|---|---|---|
| (1) S. G., aged 20. | Dysmenorrhea. Inability to void or defecate | None | October 21, 1932 | Free from pain |
| (2) F. H., aged 20. | Dysmenorrhea. Dull abdominal ache | Low grade endometritis. Cystic right ovary 5 x 2 x 1.5 cm. | June 5, 1933 | Free from pain |
| (3) O. S., aged 28. | Dysmenorrhea. Constipation | Sigmoid colon adherent to left ovary. Small cyst of right ovary | July 25, 1933 | Free from pain |
| (4) E. A., aged 27. | Dysmenorrhea. Dull abdominal ache | None | May 15, 1933 | Free from pain |
| (5) G. C., aged 34. | Dysmenorrhea. Constipation | None | December 28, 1933 | Free from pain |
| (6) V. W., aged 22. | Dysmenorrhea | None | September 19, 1934 | Free from pain |
| (7) E. M., aged 20. | Dysmenorrhea | None | May 12, 1935 | Free from pain |
| (8) C. W., aged 34. | Dysmenorrhea. Dull abdominal ache | None | June 13, 1935 | Free from pain |

which measured 5 x 2 x 1.5 cm., and contained a few cysts, was removed. It was felt that there was insufficient pathologic change to cause such pain, so the presacral nerve was resected. The patient made an uneventful recovery and she has been free from any menstrual or abdominal pain since the operation. The sacro-iliac distress was markedly relieved by a sacro-iliac belt.

Although there were some organic changes, it was felt that resection of the presacral nerve was of distinct benefit.

**Case 3.**—An unmarried woman, aged 27, had suffered from severe dysmenorrhea since puberty, but for a year the pain had become so severe that she was incapacitated for seven to ten days each month; in addition, she had noted a constant dull ache in the lower abdomen. Examinations were negative except for tenderness in both lower quadrants of the abdomen. On May 15, 1934, under Avertin anesthesia, laparotomy was

performed and the pelvic organs were found to be normal in size, position and appearance. The presacral nerve was resected and recovery was uneventful. Menstruation has been painless and the dull ache in the abdomen has disappeared since the operation.

**Case 4.**—An unmarried woman, aged 34, complained of a dull ache in the pelvis and severe dysmenorrhea to the extent that her family physician had administered as much as three-fourths grain of morphine to give relief. Seven years previously she had undergone a cholecystectomy and a year before a right cystic ovary was removed. Examinations were negative. On June 12, 1935, under avertin anesthesia, a laparotomy was performed. There were no demonstrable pathologic changes in the pelvis and a presacral neurectomy was carried out. Recovery was uneventful and the patient has remained free from menstrual pain.

The last two cases are typical of severe dysmenorrhea with pelvic plexalgia.

## CONCLUSIONS

Eight cases of dysmenorrhea, in which there was little or no pathologic change in the pelvis, were relieved by resection of the presacral nerve. This group of patients is too small to warrant general conclusions, but the results obtained seem to justify the employment of this procedure for patients suffering from severe dysmenorrhea which fails to respond to the ordinary methods of treatment.

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# EXPERIMENTAL PRODUCTION OF CHYLOTHORAX BY OCCLUSION OF THE SUPERIOR VENA CAVA*

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IN THE course of some experiments on dogs in which attempts were being made to produce the condition known as traumatic asphyxia, the superior vena cava was ligated. Much to our surprise, the immediate effect of the occlusion was almost negligible. The first of our animals, in which the superior cava was ligated, became short of breath 12 days following the operation and died on the following day. Autopsy revealed the presence of 900 cc. of milky fluid in the pleural and pericardial cavities.

As a result of this observation, further studies have been carried out. The findings dealing in particular with the incidence of chylothorax following occlusion of the superior cava are detailed. Other studies concerning the cytology and chemistry of the fluid will be reported later.

METHOD.—Dogs were used as the experimental animals in some instances and cats in others. Under ether or nembutal anesthesia and using positive pressure through an intratracheal catheter, the right side of the chest was opened through an intercostal incision. The superior vena cava was carefully separated from the surrounding structures and it was doubly ligated with silk just distal to the entrance of the azygos vein. The incision in the chest was closed.

The chest was aspirated from time to time in order to obtain fluid for study and for the purpose of relieving dyspnea. In some instances the animals were allowed to die, while in others they were sacrificed.

Venous pressure determinations were carried out in most of the studies on dogs both before and at various intervals following the operations. The veins used were the external jugular and femoral. The method employed was that in which salt solution is allowed to flow into the vein from a burette until the level of the venous pressure is reached.

In four experiments, occlusion of the superior cava was preceded by ligation of the thoracic duct.

RESULTS.—The superior cava was ligated in 13 dogs. Bloody fluid was aspirated from the chest of most of these several days following the operation. Chyle was obtained later from the pleural cavities on aspiration in seven of the

* This work has been aided by a grant to Vanderbilt University from the Division of Medical Sciences of the Rockefeller Foundation.

13 animals. The length of time separating the operation and the appearance of the chyle, the duration of the chylothorax and the quantity of chyle were variable factors in the different experiments.

The interval of time separating the operation and the obtaining of chyle on aspiration varied from nine to 25 days in the seven experiments, the average time being 17 days. These figures are not absolute as chyle may have been present but not detected on aspiration. The fluid reaccumulated rapidly in some animals and slowly in others. Two of the animals died 13 and 18 days following the occlusion of the superior cava and 900 and 1,100 cc. of chyle were present in the pleural cavities. A small quantity was found in the pericardial cavity. Death was due almost certainly to the reduction in vital capacity resulting from the collapse of the lungs by the fluid. One animal which had had chyle in the pleural cavity previously had only bloody fluid at the time of death. Two animals were killed 15 and 27 days following the operation and 935 and 700 cc. of chyle were present in the pleural cavities. In the remaining two dogs of this series, chyle ceased to accumulate in the pleural cavities 34 and 44 days following the operations and the experiments were terminated.

The venous pressure as measured in the external jugular vein rose immediately in all experiments following the occlusion of the superior cava. From a level of slightly less than zero, the pressure rose approximately 200 Mm. $H_2O$. There was a gradual decline from this point as the venous collaterals increased in size, but usually the pressure did not return entirely to the preoperative level. The height to which the venous pressure rose following the operation did not seem to determine whether or not a chylothorax ensued. The venous pressure readings as determined in the external jugular vein at the time that the first chyle was aspirated in the seven experiments were 190, 140, 145, 135, 100, 75 and 30 Mm. $H_2O$. It is to be noted that the venous pressure was 100 or greater in most of the experiments but it is of interest that chyle appeared in one instance in which there was little elevation in the pressure. In this latter study, the venous pressure was 175 Mm. $H_2O$ on the day following the occlusion of the superior cava. Four days later, the pressure had declined to 60 Mm. $H_2O$ and blood-tinged fluid was aspirated from the chest. Six days subsequently, the jugular pressure was 20 Mm. $H_2O$ and blood-tinged fluid was obtained from the chest. Chyle was aspirated from the chest 13 days later and the venous pressure was 30 Mm. $H_2O$. The animal was killed two days subsequently and 700 cc. of chyle were found in the pleural and peritoneal cavities. The thoracic duct and azygos vein were patent at autopsy. There was less distention of the lymphatics of the mesentery of the intestines in this experiment than in most of the others in which chylothorax was present. The mediastinal tissues in this and other experiments were markedly edematous and an incision into them resulted in the escape of a considerable amount of milky fluid. The mediastinal lymph nodes were greatly enlarged and filled with chyle. There was no evidence of previous injury to

the pleura or other structures. The findings indicated that the chyle entered the pleural cavity through an uninjured pleural layer.

In some instances in which the mesenteric lymphatics were injected with Berlin-blue, the material did not pass beyond the regional lymph nodes where diffuse rupture took place. The force required for the injection indicated an increase in the intralymphatic pressure. There was marked edema of the neck, chest and anterior extremities in two of the experiments.

As has been stated, occlusion of the superior cava was preceded by ligation of the thoracic duct in experiments on four dogs. The method which was used for the occlusion of the thoracic duct was that described by Lee[4] in which the duct, together with the covering of the thoracic aorta, and the azygos vein are included in the ligature. It was performed at approximately the level of the seventh thoracic vertebra. No fluid was obtained on aspiration of the chest following this procedure. After an interval of seven to 13 days, the superior cava was doubly ligated. Chylothorax did not result in any of these studies, and no more than 15 cc. of blood-tinged fluid were obtainable on aspiration on any one occasion.

Twenty-three experiments were performed upon cats, in whom the superior vena cava was ligated. Chylothorax was produced in 14 of these. The length of time separating the operation and the obtaining of chyle on aspiration varied from four to 49 days, the average time being 22 days. However, in the two experiments in which the interval was 49 days, aspiration had not been attempted during the preceding 34 days. Several of the cats died as a result of the accumulation of large quantities of chyle in the pleural cavities. More frequent aspirations would probably have prevented the death of these animals. In other instances, repeated aspirations were followed by the disappearance of the chylothorax. In still other experiments, the animals were killed before the accumulation of chyle had ceased. The details of an experiment in which rather large quantities of chyle were aspirated from time to time are given below.

TABLE I

FAT CONTENT IN CHEST FLUIDS (CAT. NO. 20)

| Date | Quantity Fluid cc. | Gm. Fat per 100 Gm. Fluid | Date | Quantity Fluid cc. | Gm. Fat per 100 Gm. Fluid |
|---|---|---|---|---|---|
| July 18 | 40 | 0.58 | Aug. 16 | 105 | 3.33 |
| July 22 | 20 | | Aug. 20 | 25 | 1.68 |
| July 29 | 30 | 1.69 | Aug. 24 | 170 | 2.58 |
| Aug. 3 | 140 | 2.02 | Aug. 26 | 150 | 2.04 |
| Aug. 6 | 50 | | Aug. 30 | 105 | 0.79 |
| Aug. 10 | 125 | 3.66 | Sept. 2 | 35 | 3.09 |
| Aug. 13 | 112 | 3.88 | Sept. 6 | 185 | 2.50* |

* Postmortem.

Cat No. 20, weight 2.6 Kg. The superior vena cava was doubly ligated June 28, 1935. Aspiration of the chest was negative for fluid July 5 and 8, 1935, but 6 cc. of blood-tinged fluid were aspirated July 12, 1935. The first chyle was obtained four days later, July 16. On subsequent days the amounts shown in Table I were secured. The cat died September 6. There were 185 cc. of chyle in the two pleural cavities and a small quantity in the pericardium. Many small lymph vessels were visible in the neighborhood of the intercostal vessels. There was no free chyle in the peritoneal cavity. The lymphatic vessels in the mesentery of the intestine were distended with chyle. No evidence of infection was found. There had been very little loss in weight. The mechanical effects of the presence of the fluid probably caused the death of this animal.

The following chemical studies were made on fluids from this animal. Total fat determinations by the ether extraction method were made (Table I).

On three fluids the lipid partition was determined according to the method of Kirk, Page and Van Slyke[1] (Table II).

TABLE II

LIPID DISTRIBUTION IN CHEST FLUIDS (CAT. NO. 20)

| Date | Total Lipid C | Total Lipid P | Total Lipid N | Total Cholesterol | Free Cholesterol | Bound Cholesterol | Cholesterol Esters Calc. | Phosphatides Calc. | Neutral Fats Calc. | Total Lipids Calc. | Total Lipids 1.3 × Lipid C |
|---|---|---|---|---|---|---|---|---|---|---|---|
| July 18 | 505.2 | | 3.5 | 130.1 | 72.8 | 57.3 | 96.9 | | | | 656.8 |
| July 29 | 1874.6 | 13.1 | 6.9 | 84.6 | 63.3 | 21.3 | 36.0 | 308.7 | 2097.8 | 2595.8 | 2437.0 |
| Sept. 6 | 2521.4 | 10.9 | 8.3 | 111.3 | 66.5 | 44.8 | 75.7 | 257.8 | 2948.4 | 3348.9 | 3277.8 |

In spite of the quantity of phosphatide present, the high cholesterol and total fat contents of these fluids place them definitely in the group of true chylous fluids, as distinguished from pseudochylous fluids by Wallis and Schölberg.[2] According to these authors, chylous fluids contain cholesterol, little or no lecithin and have a fat content of 0.4 to 40 per cent. Pseudochylous fluids, on the other hand, are rich in lecithin but contain little or no cholesterol.

The relation between these fluids and blood and lymph will be discussed in a later paper.

The chest fluids found in these animals have been studied for their cellular content by the supravital method. Table III gives the cellular picture as found in a typical animal (Cat. No. 20).

*Discussion.*—Carlson[3] reported recently his experimental studies on the effects of occlusion of the superior cava. He found that dogs tolerate obstruction of the superior cava above the level of the azygos vein but not obstruction including the azygos when it is produced in one stage. A rise in venous pressure was noted and the development of collateral venous pressure was studied. The development of chylothorax was not observed by Carlson in the seven experiments which he performed. He stated: "Except in two dogs that died of empyema, pleural effusions did not develop in the dogs in which obstruction above the azygos vein had been carried out. In the only dog that was subjected to preliminary obstruction of the azygos vein a sanguinous effusion developed, from which he recovered within two weeks."

TABLE III

TOTAL AND SUPRAVITAL CELL COUNTS IN CHEST FLUIDS (CAT. NO. 20)

| Date | Quantity Fluid cc. | Total W.B.C. | White Blood Cell Differential | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | P.M.N. | P.M.E. | Lymph-ocytes | Mono-cytes | Clasma-tocytes | Serosal Cells |
| July 12 | | 5,600 | 2,688 | 168 | 2,464 | 280 | .. | .. |
| July 16 | | 20,000 | 2,300 | 400 | 16,800 | 500 | .. | .. |
| July 18 | 40 | 12,800 | 1,984 | 192 | 9,472 | 512 | 640 | .. |
| July 22 | 20* | | | | | | | |
| July 29 | 30 | 10,000 | 3,500 | 500 | 5,800 | 100 | 100 | .. |
| Aug. 3 | 140 | 6,800 | 1,632 | ... | 4,420 | 544 | 204 | .. |
| Aug. 6 | 50 | 10,400 | 5,720 | 312 | 3,640 | 624 | 104 | .. |
| Aug. 10 | 125* | | | | | | | |
| Aug. 13 | 112 | 16,400 | 12,300 | 328 | 2,952 | 328 | 164 | 328 |
| Aug. 16 | 105 | 7,200 | 2,916 | 72 | 3,456 | 648 | 36 | 72 |
| Aug. 20 | 25 | 10,720 | 5,038 | 642 | 5,038 | ... | .. | .. |
| Aug. 24 | 170 | 5,520 | 3,202 | ... | 2,153 | ... | 165 | .. |
| Aug. 26 | 150 | 9,920 | 4,364 | 99 | 4,464 | 594 | 396 | .. |
| Aug. 30 | 105 | 12,000 | 4,200 | 180 | 7,500 | 120 | .. | .. |
| Sept. 2 | 35 | 9,840 | 7,970 | ... | 1,870 | ... | .. | .. |
| Average | | 10,554 | 4,447 | 223 | 5,387 | 327 | 139 | 31 |

* No cell counts made on these fluids.

It is of interest to speculate as to the manner in which occlusion of the superior cava results in chylothorax and chylopericardium. It is well known that occlusion of the left thoracic duct does not result in this condition. We have observed recently that ligation of the right and left thoracic ducts does not cause chylothorax. The fact that occlusion of the superior cava results in the accumulation of chyle in the chest, while occlusion of the main right and left ducts does not, indicates that there are a number of other lymph vessels which empty into the superior cava or its branches. This would be anticipated from work of Lee,[4] who found lymph vessels which entered the intercostal veins. These veins, however, empty into the azygos which was not occluded in our experiments. Lee occluded the thoracic duct by an intrathoracic method and his findings as regards the collateral circulation are as follows: "As a result of these dissections, two general types of collateral circulation were established. The one type consisted of a collateral circulation to the right thoracic duct, the other type comprised those cases in which the lymph entered the azygos vein or its branches."

It is likely that there are lymphaticovenous communications in the peritoneal cavity. This was suggested by Lee. If so, these would be expected to dilate in the presence of superior caval obstruction. It would seem that obstruction to the flow of lymph would be most marked immediately following the occlusion of the superior cava. However, the fact that chyle does

not appear in the thorax for a number of days does not support this viewpoint, although it does not disprove it.

We are unable to state from the present experiments what part, if any, the venous blockage per se played in the production of chylothorax. One is unable to occlude the superior cava without causing some interference with the flow of lymph. Experiments are now being carried out in which attempts are being made to produce lymphatic obstruction without venous ligation.

## SUMMARY

In experiments on dogs and cats in which the superior vena cava was ligated, approximately one-half of the animals developed chylothorax, and chylopericardium was present in some of these.

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# ACUTE SUPPURATIVE PERICARDITIS

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ACUTE suppurative pericarditis has been recognized clinically since the early days of medicine. "Galen noted it in animals and characteristically made the bold deduction that man could likewise suffer from the disease." Riolan, in 1649, advocated pericardiotomy for the relief of pericardial effusion. In the last century Laennec, Corvisart, and Auenbrugger drew attention to the physical signs of the disease. Indeed, the former advised Riolan's plan of trephining the sternum. Romero, in 1819, was the first to perform a successful pericardiotomy.[1]

In the last 40 years the surgical treatment of pericarditis has received much attention in surgical literature. Still, in 1933, Truesdale[14] was able to collect only 152 reported cases treated by pericardiotomy. He emphasized the steady improvement in the mortality from 65 per cent in the 52 cases reported by Porter and Roberts[9] in 1900 to 42 per cent for the entire series of 152 cases.

While suppurative pericarditis is not a clinical rarity, the paucity of reported cases clearly indicates that the profession at large is not aware of the advances in therapy which have occurred, and most of the sufferers from the disease are not given the benefit of surgical treatment.

Suppurative pericarditis is as much a surgical disease as empyema. As in empyema, there is a closed collection of pus, with the danger of toxemia and septicemia. In addition, the mechanical pressure on the heart, already weakened by the disease, is a more serious factor than the mechanical pressure in empyema.

We are presenting a case of acute suppurative pericarditis in an infant successfully treated by pericardiotomy, which happens to be the youngest among the survivors (Fig. 1). The procedure used failed to permit satisfactory exploration of the pericardium. As the Rhodes[10] operation has been frequently criticized from this standpoint and for allowing pocketing posteriorly, and as some hazardous procedures have been advocated to overcome its shortcomings, it has seemed worth while to call attention, briefly, to Allingham's[2] operation which has received scant notice in most discussions on technic, although we have had no opportunity to put it to the test.

**Case Report.**— T. H. aged 18 mos. Admitted to St. Mary's Hospital for Children June 5, 1933. C. C. Cough. P. I. Had measles in March followed by pneumonia. Was admitted to Bellevue Hospital from which he had been discharged three weeks previously. Since then has had continuous cough, with recurrence of fever, dyspnea, loss of appetite, and malaise. P. H. Pneumonia of left lung at 6 mos. Treated at St. Mary's Hospital. P. X. T. 103.6°, P. 160, R. 80. Breathing suppressed over right

lung with many crackling râles over lower part of right lung and in axillary line. P. D. Bronchopneumonia of right lung. Roentgenogram shows pathology involving lower two-thirds of the right lung (Fig. 2). 6/9/33 W.B.C. 18650, P. 78, L. 22.

*Course.*—6/23 Exploratory thoracentesis, no fluid. Generally improved. 7/8 Meningitic symptoms. Spinal puncture. Clear fluid, three cells, no organisms. 7/10 Signs of pericardial effusion. Cardiac dulness markedly increased. Apex beat diffuse in anterior axillary line and in third, fourth and fifth interspaces. Sounds of fair quality. Slight precordial bulge. No murmurs or friction rub. Dulness and bronchial breathing in left lower posterior chest.

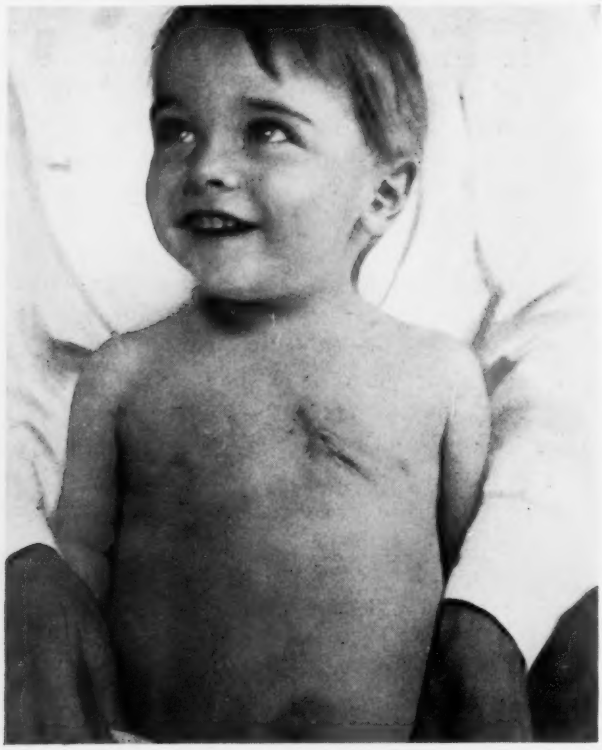

FIG. 1.—Photograph of patient one year after pericardiotomy.

*Roentgenologic Examination.*—Cardiac shadow is roughly oval in shape, greatly enlarged and indicates the presence of a pericardial effusion (Fig. 3).

Pericardiocentesis in fourth interspace to left of sternum. 18 cc. cloudy, lemon-yellow fluid removed. 11,600 cells. Culture, pneumococcus type iv.

*Operation.*—Local anesthesia, hockey-stick incision over sternum from second to fifth costal cartilage. Lateral extension over left fifth costal cartilage. Fifth costal cartilage excised and fourth and third divided at sternum. Flap raised. Subcostal muscles incised and internal mammary artery exposed and retracted medially. Pericardium exposed and pleura separated to left. Pericardium appeared opaque and thick. Divided vertically between stay sutures. Several ounces of cloudy fluid evacuated. Incision too high to permit exploration beneath or behind the heart. Heart and pericardium covered with fibrin one-quarter inch thick. The heart lay anterior, presenting at the opening in the pericardium. Soft rubber catheter inserted over left ventricle and sutured to chest wall. Wound partially closed about drain. Immediately after operation pulse dropped to 120 and quality distinctly improved. Culture—pneumococcus.

FIG. 2.—Roentgenogram, June 5, 1933, showing pneumonia involving the right middle and lower lobes.

FIG. 3.—Roentgenogram, July 1, 1933, showing pericarditis with effusion.

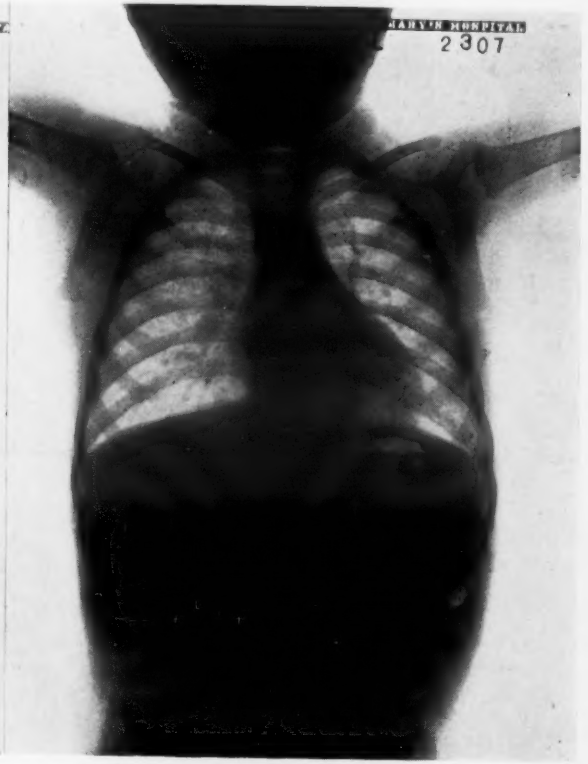


FIG. 4.—Roentgenogram, September 26, 1933, after drainage of the pericardium.

7/14 Rubber tube removed. Temperature normal on twelfth day and remained normal for two weeks. 7/28 Abscess right thigh opened. Culture pneumococcus. Wound of chest completely healed in six weeks. Convalescence slow with frequent setbacks and continuation of cough, rapid pulse and dyspnea. 9/26 Discharged (Fig. 4).

*Diagnosis.*—The diagnosis is not always evident, as is shown by the legion of physical signs which have been described as characteristic of pericardial effusion. The increased area of cardiac dulness, precordial bulging, diffuse and wavy apex beat, area of dulness and bronchial breathing in left lower chest posteriorly, are most commonly found. These signs accompanied by dyspnea, orthopnea, septic temperature, weak, rapid pulse, cyanosis and leukocytosis, should suggest the diagnosis.

*Fluoroscopic Findings.*—We also wish to call attention to the fluoroscopic findings which are believed to indicate the presence of fluid in the pericardium. If further investigation confirms these findings, they will be of considerable value in differential diagnosis.

FIG. 5.—Schematic drawing of pericardium as seen under fluoroscope. Dotted lines represent fluid waves set up by contractions of the heart. These arise and are most marked near the base and descend to the diaphragm along the lateral margins. They seem to occur at systole and immediately after.

In pericardial effusion the heart shadow is much enlarged and globular in shape. At first glance there appear to be no contractions. On closer scrutiny slight systolic contractions can be seen at systole, but the excursion is markedly decreased. Small fluid waves were seen following systole, which arose at the base and passed down the upper left margin toward the apex, and down the right border toward the diaphragm (Fig. 5). These fluid waves, we believe, are pathognomonic of fluid in the pericardium.

As far as we know, such waves have not been described. Theoretically, such a phenomenon would appear logical. Fluid is present about the heart in a closed cavity with elastic walls. As the heart suddenly contracts at systole, the tension within the pericardium is lessened, and a disturbance of

the fluid is set up, causing fluid waves which subside as the tension is more gradually increased during systole.

We have had, as yet, only one other opportunity to check these findings. That was in a case of pericardial effusion, confirmed by physical signs and repeated roentgenograms only. The same phenomena were observed.

Obviously further confirmation of these findings is necessary to establish them as a sine qua non of fluid in the pericardium. The observation is offered with the hope that interest may be aroused in fluoroscopy of pericardial effusion and its value established. If fluid waves are always present, this sign would be of great value in eliminating enlargement of the heart from other causes.

*Operative Technic.*—The operation which is most popular was first described by Rhodes.[10] It consists of a hockey-stick incision down the left side of the sternum with a lateral extension over the fifth or sixth costal cartilage. The fifth or sixth cartilage is excised and as many more may be divided as is necessary for a full exposure. The pericardium is exposed and the pleura, if present, gently pushed to the left by blunt dissection. The pericardium is opened vertically and thoroughly explored with the finger to separate any adhesions and open any pockets. Local anesthesia is preferable.

At operation, it was evident that in the dorsal position the heart tended to obstruct drainage. It was felt that this was partially due to its floating upward on the fluid, and that this tendency would be combatted by the prone position, as well as permitting dependent drainage for the fluid behind the heart. Drainage seemed to be facilitated by this procedure.

An adhesive pericarditis might be expected as a sequela, although in younger patients it would not be so likely as in adults. In our case there was no evidence of impairment of the heart, the only abnormality being the weakness of the thoracic wall, due to failure of the costal cartilages to reunite. So far as we are aware, there have been no instances of serious cardiac impairment among the survivors. Shipley[12] writes, "Of the six patients upon whom I have operated for pyopericardium and who recovered, I have kept track of five and no one of the five is disabled." Williamson,[17] in commenting on his case reports, "There is today no evidence of a heart crippled by adhesions to surrounding pericardium."

The best operative approach to the pericardium in suppurative pericarditis is still a debatable question and merits consideration. There is a definite objection to anterior median drainage. The anterior position of the heart in the pericardium tends to obstruct the drainage tract and allow pocketing, especially posteriorly. This may be partially overcome by creating a fairly large defect in the pericardium, postural drainage (*i.e.*, prone position) as suggested by Peterson,[7] by the use of drainage beneath the heart, and by flushing the pericardium with fluids as advocated by Pool.[8] In Truesdale's[14] case the Rhodes' technic failed to obtain satisfactory drainage. The difficulty

was overcome in the second, and successful, case by a second horizontal incision in the seventh interspace from the nipple line to the posterior axillary line, with resection of two inches of the seventh and eighth ribs. Fortunately, the pericardium was in contact with, and adherent to, the pleura, as well as adherent to the visceral pleura of the lung, so that it was possible to open the pericardium beyond the apex of the heart without opening into the free pleural cavity. Through-and-through irrigations were employed for a few days and the patient went on to a complete recovery.

"In Loucks' successful case the anterior incision failed to promote recovery and he resorted to posterior drainage of the pericardium through a thoracotomy wound which had been made for empyema. . . . In commenting upon his experience the author states that the posterior drainage has certain natural advantages. It is the method of choice only in cases in which, because of an existing pleuritis or empyema, there is reasonable evidence that the main pleural cavity has been sealed off from the operative field" (Truesdale[14]).

The second case quoted by Loucks[6] was operated upon by Heuer. The usual anterior incision was made but the two layers of the pericardium were adherent and the fluid could not be evacuated. An incision was made through the posterior axillary line. The lung was adherent to the parietal pleura and compressed by the pericardial fluid. An incision was made deliberately through the lung and temporary improvement was obtained. The pericarditis was secondary to an actinomycosis of the spine and the patient died subsequently.

Transpleural drainage according to Loucks was employed successfully in a case by Stewart and Garrod. They had resected the left eighth rib in the scapular line for empyema. Three weeks later they incised a bulging pericardium through the same incision. West recorded a similar successful case, and Libby a case that died. Brinton and Collins reported an operation upon a case of suppurative pericarditis in which they incised through the fifth interspace in the anterior axillary line, supposing it to be an empyema, which resulted in a collapse of the lung and a mortality a few hours later.[6]

Obviously Truesdale's and Loucks' solution, for lateral or posterior drainage, is applicable only under certain specific, favorable conditions and in the ordinary case is fraught with great danger of collapse of the lung and soiling of the pleural cavity.

Allingham,[2] following an unsuccessful drainage by removal of two inches of the fifth costal cartilage, devised an ingenious operation upon cadavers, which was successfully employed three decades later by Thomas[13] in a case of pericarditis secondary to an acute osteomyelitis of the femur.

Briefly, he advocated an upper left rectus incision and an extraperitoneal approach through the diaphragm and pericardium. He claims for this procedure safety from contamination or injury of the pleura, dependent drainage, and great ease for exploration of the heart to its extreme limits. It would also preserve the integrity of the thorax over the heart.

In our case the incision was too high to permit adequate exploration beneath the heart, and we were fortunate that pocketing did not occur. It would appear that excision of the sixth or even seventh costal cartilage would facilitate exploration. Shipley's[11, 12] combined transsternal and transchondral approach is an excellent method for the attainment of these ends. He makes a trephine opening in the sternum adjacent to the attachment of the fifth, sixth, and seventh costal cartilages. The ends of as many cartilages as desired may be cut away permitting good exposure and a well placed approach.

Allingham's epigastric incision seems to merit further trial. Its advantages have been adequately described and resulted, in Thomas' hands, in a cure of one of the few survivors, in whom osteomyelitis was the etiologic focus. It also does not result in a permanent weakness of the thoracic wall.

## SUMMARY AND CONCLUSIONS

(1) Truesdale collected 152 cases of suppurative pericarditis treated by pericardiotomy with a 42 per cent mortality.

(2) Incision should be low and the pericardium adequately opened.

(3) Allingham's epigastric incision has been neglected and appears to merit further trial.

(4) The case cited is the next to the youngest reported, and the youngest of the survivors.

(5) Pick's disease is not to be anticipated as a sequela of surgical drainage of the pericardium.

I wish to express my appreciation to Dr. Dever S. Byard, Dr. Charles E. Farr and Dr. Edward D. Truesdell for permission to report this case.

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# GASTRODUODENAL SURGERY

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THE following remarks are based on observations made at various clinics on the mainland and in Europe, from current literature, and from personal experience during the past 12 years with 188 operative procedures for gastroduodenal lesions.

Perhaps no other surgical problem of the abdomen has been so widely discussed within recent years, in an attempt to rationalize its treatment, as has that of duodenal ulcer. Many of the problems have been clarified, many yet await solution. It has been the experience in the past that until the etiology of a disease was known its complete control or even logical treatment was not accomplished. Until we know in a more exact manner the exciting causes of ulcers, why certain individuals have a so called ulcer diathesis, why the symptoms are intermittent in nature, why gastric ulcers are prone to undergo malignant degeneration and duodenal ulcers very rarely do, and the why and wherefore of many other phases of this common malady, we will continue to grope about in the fog of uncertainty, adopting that scheme of therapy which is receiving the popular acclaim at the moment.

In attempting to evaluate the relative merits of medical versus surgical treatment, it is at once apparent that the internist cannot be certain in a relatively high percentage of cases whether the condition which he is treating for ulcer is actually that or some other pathologic condition simulating ulcer. Again the life cycle of ulcer symptoms is one of recrudescence and the impression may be gained that a cure has been effected when in reality symptoms are but quiescent. On the other hand, end-results following surgery are difficult to obtain. Many of the complications may be years in developing, an accurate follow up is laborious, frequently inaccurate, and the human equation when stimulated by an undue amount of enthusiasm may be hard to evaluate.

However, one may safely say that unless an emergency exists, such as perforation or at times hemorrhage, operative interference in cases of duodenal ulcer is to be considered only when medical treatment has been conceded to be a failure. Our experience has been that the success of medical treatment depends to the greatest extent on the financial status of the patient plus his willingness to cooperate with his medical attendant. In the laborer whose daily toil furnishes the only means of sustenance for himself and family, whose dietetic regimen cannot be supervised and whose periods of rest and recreation are practically nil, the outlook for nonoperative cure is small in comparison to the individual who has everything at his command and is willing to avail himself of his opportunities for recovery.

Gastric ulcers, on the other hand, are to be viewed with suspicion from the beginning due to their potential possibilities of being or of becoming malignant. If not responding readily to a medical regimen they are candidates for surgery and here more radical surgery is generally recommended than when dealing with a duodenal ulcer.

Surgery of carcinoma of the stomach, with few exceptions, is even more disappointing than that for most organs whose complete extirpation is compatible with life. The lesion is usually so far advanced before being diagnosed that radical removal if at all feasible offers little hope for permanent cure. With few exceptions palliative measures are scarcely worth the effort expended by the surgeon, which is negligible compared to the mental and physical anguish experienced by the patient. If his life is prolonged it is usually, as someone has said, to the end that he may suffer more. The one redeeming feature and the one that usually justifies exploration is the fact that what appears to be a malignancy at times proves to be an inflammatory process. Until such time when our diagnostic procedures enable us to bring the patient with carcinoma of the stomach to the surgeon in its early localized state, the results from surgery will continue to offer little that will alleviate his plight and practically nothing toward his permanent cure.

When for various accepted reasons the patient with a duodenal ulcer is subjected to operation, we have for consideration a number of procedures that have given more or less satisfactory results in the majority of people's experience. Under this heading may be mentioned the various pyloroplasties, gastroduodenostomy, gastro-enterostomy with or without a direct attack on the ulcer, subtotal gastric resection and pyloric exclusion.

The first of these, pyloroplasty, when applicable, is the most conservative of all the procedures and has the distinct advantage in that the gastric content continues to empty into the duodenum where it is least likely to give rise to a marginal ulcer. It has been shown both clinically and experimentally that the incidence of marginal ulcer develops in direct proportion to the nearness with which the anastomosis between stomach and small intestine approaches the ileocecal valve. When the ulcer lies on the anterior or superior portion of the duodenum it may at times be easily excised and the incision prolonged across the pylorus into the stomach and converted into a pyloroplasty by approximation of its extremities. By this simple procedure the ulcer is removed, the sphincter action of the pyloric muscle abolished, temporarily at least, the outlet of the stomach enlarged to allow quicker emptying time, and regurgitation of alkaline duodenal contents into the stomach to neutralize gastric acidity is brought about. Unfortunately, in many cases due to the inflammatory reaction about the ulcer or to the anatomic construction of the duodenum, pyloroplasty is not mechanically feasible. The descending portion of the duodenum may then be found mobile or capable of being mobilized by freeing it of its lateral peritoneal attachment permitting of gastroduodenostomy, anastomosing the duodenum along the

greater curvature of the stomach in the region of the pylorus. Needless to say, it is essential here as elsewhere in gastro-intestinal work to make the anastomosis without tension.

On a recent visit to Professor Wilkie's Clinic in Edinburgh this method of short circuiting the gastric outflow below the sight of the ulcer was demonstrated on several occasions, and the value of this method emphasized. The operator had used this method for many years and was pleased with the results, finding it especially valuable and preferable to gastro-enterostomy in those cases where there was a high gastric acidity.

With the lapse of time allowing for longer and more accurate observation of end-results the high esteem in which posterior gastro-enterostomy was held in the treatment of duodenal ulcers would appear to be definitely on the wane. Hinton and Church,[1] in a recent article on observations made in the follow up clinic in Bellevue Hospital, found an incidence of 16.4

FIG. 1.—Gastroduodenostomy for duodenal ulcer.

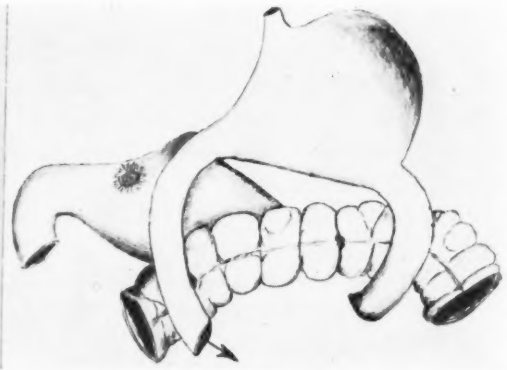

FIG. 2.—Showing a method of pyloric exclusion for gastric ulcer.

per cent of marginal ulcers following gastro-enterostomy. In 79 cases, the greater majority of which had been followed for less than five years, there were 13 gastrojejunal ulcers, three occurring after seven years. They emphasize the necessity of a ten year follow up in determining end-results. Lewisohn and Berg[2] have for a number of years insisted on the high incidence of marginal ulcer following this operation and reported an incidence of about double that of Hinton. Our experience with increasing data has been that the operation is one that has limited value. Too frequently the patient after a period of freedom from symptoms presents himself later because of epigastric pain, distress, or hemorrhage, and the symptoms are found to be due either to a new duodenal ulcer, reactivation of the old one, or a marginal ulcer.

In an individual of middle age or beyond where symptoms have been of long duration, whose pylorus is markedly obstructed from scar tissue and adhesions and where gastric acidity is near normal, posterior gastro-enterostomy may be expected to give brilliant results. The principal redeeming feature of the operation, or perhaps it would be more accurate to say fallacy,

is that the technic of its execution is comparatively simple and the operator of limited experience feels justified in attempting its use.

One of the admonitions of the teacher of obstetrics is, "never pull on the umbilical cord in attempting to deliver the placenta for if it should pull off there is nothing left to pull on." This reminds me of the advocates of conservative surgery in the treatment of duodenal ulcers. Their admonition is, "never do a subtotal gastric resection as a primary operation in the treatment of duodenal ulcer, for if a marginal ulcer should develop then there is nothing left to resect." Marginal ulcers have occurred following subtotal gastric resection but even the most skeptic, I think, will have to admit that the incidence is small indeed as compared to that following gastro-enterostomy. Our end-results certainly have been much more satisfactory when resection was used instead of more conservative measures. With proper skill and experience the mortality from subtotal resection can be kept at a figure that would seem justifiable in the treatment of both gastric and duodenal ulcers.

Straus, *et al.*,[3] in a recent article, report a mortality rate of 3.8 per cent in free ward cases and less than 2 per cent in private patients, a record so far as I know that has not been equaled by anyone else.

In 1925,[4] and again in 1928, Devine[5] of Australia called attention to the principles of pyloric exclusion in the treatment of duodenal ulcers. He recommended it particularly in old callus ulcers on the posterior wall of the duodenum when resection of the ulcer was difficult and dangerous and when recurrence of the ulcer occurred after gastro-enterostomy. He found that the nearer the resection of the stomach was made toward the cardia the more rapid was the emptying time and the greater the regurgitation of the alkaline duodenal contents as shown by the inorganic chloride curve. The free hydrochloric acid was lower and the end-results more satisfactory. In fact, gastric analysis was the same or perhaps a little better than in a gastric resection. Thus, he says, was evolved an operation as simple as a gastro-enterostomy giving the same results without the mutilation of a gastrectomy. He points out that if a reestablishment of the original condition seems desirable all the structures are available. It is necessary in his experience to exclude from one-half to two-thirds of the stomach to secure uniformly satisfactory results. This is best accomplished by making the section of the stomach very obliquely so as to include more of the gastric canal and exclude as much as possible of the fundus and its acid producing glands.

In ten cases I have used the principle of pyloric exclusion as recommended by Devine and the results so far have been most satisfactory. This method proved to be of particular value in a debilitated individual whose ulcer, some months following suture for perforation, began to bleed intermittently but alarmingly. Exploration after repeated transfusions revealed a large indurated prepyloric ulcer adherent to the pancreas. The patient probably would not have survived anything more radical than a pyloric exclusion and anything of less magnitude probably would not have relieved the symptoms. It has now been three years since operation and there has

been no return whatever of gastric symptoms. The warning by Devine of the inapplicability of this procedure in the presence of any pyloric obstruction was not sufficiently heeded in one instance. Subsequent to operation distension of the distal segment was palpable through the abdominal wall but fortunately a tube was inserted before rupture into the abdominal cavity occurred. Subsequently the pyloric obstruction subsided under rest and the gastrostomy opening healed.

A more widespread utilization of the principle of pyloric exclusion from my small but very satisfactory series would seem justifiable.

In the surgical treatment of gastric ulcers subtotal resection, I believe, is the operation of choice. It offers the greatest reassurance against recurrence and the possibility of the ulcer being or becoming malignant must never be lost sight of, hence the advisability of wide excision. Local excision of ulcers such as saddle excision of those along the lesser curvature give a high percentage of unsatisfactory results due to interference with gastric motility. If this method of treatment is to be used it should always be combined with a posterior gastro-enterostomy. Our experience with three cases in which a subsequent gastro-enterostomy had to be done to relieve retention has fully convinced me of the correctness of this conclusion. Sleeve resection for the same reason is a procedure that has little in its favor.

One condition that may closely simulate a lesion producing pyloric obstruction is that of constriction of the terminal duodenum by the superior mesenteric vessels. A brief résumé of such a case may prove instructive though reflecting little glory on the acumen of the surgeon.

The patient with a history of abdominal distress, nausea and vomiting with a large six hour retention was operated upon with a preoperative diagnosis of pyloric obstruction probably from a cicatrizing duodenal ulcer. No ulcer could be found from external investigation of the duodenum so an incision was made across the pylorus extending above into the stomach and below into the duodenum. Inspection of the interior of the duodenum was negative. The ends of the incision were approximated, converting the exploratory incision into a pyloroplasty. The subsequent course was that of aggravation of the symptoms of pyloric obstruction and roentgenograms showed persistence of the gastric retention. It was then thought that a gastro-enterostomy would relieve the symptoms, but this also failed in its mission. The gastric retention was relieved but the patient continued to vomit and complain of severe pain across the middle of the back. At no time did the roentgenologic investigation suggest duodenal obstruction, though this was thought of, and search for this condition carefully made. At the third operation nine months after the first, which was of an exploratory nature, with the thought in mind that a marginal ulcer might be present, no ulcer was found but a very definitely constricted terminal duodenum with dilatation proximally caused by the superior mesenteric vessels being drawn tightly across the duodenum. A pyloric exclusion was done by severing the stomach just distal to the gastro-enterostomy stoma. A duodenojejunos-

tomy was then made anastomosing the jejunum just distal to the gastro-enterostomy stoma to the third portion of the duodenum. Subsequent to the third operative procedure the patient made a very satisfactory recovery both as regards the nausea and vomiting and the pain in the back. The

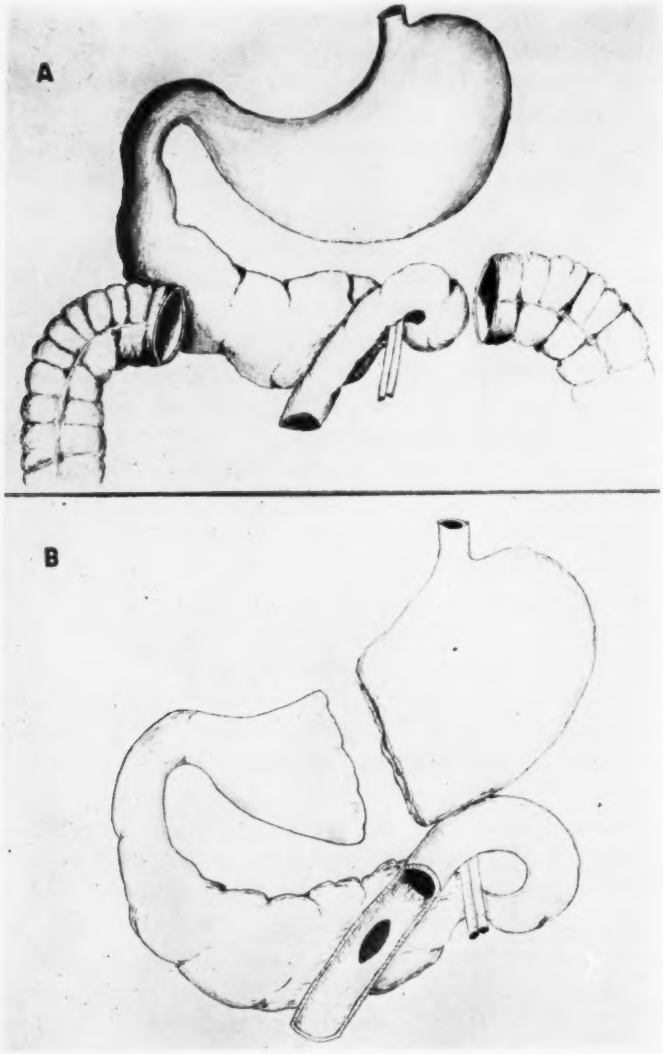


FIG. 3.—(A)—Obstruction of duodenum by superior mesenteric vessels. (B)—Showing gastro-enterostomy, pyloric exclusion and duodenojejunostomy used in treatment of case discussed in text.

lesson I have learned from this distressing case is to always investigate the duodenum, being especially careful to do so when not enough pathology is found higher up to account for the symptoms.

Acute perforation of the stomach or duodenum has been encountered 20 times. In the majority of instances the perforation was in juxtaposition

to the pylorus, it frequently being impossible, due to surrounding inflammatory changes, to determine whether the ulcer was duodenal or prepyloric. In no instance, so far as we have been able to determine, was the perforation the result of malignancy. When the perforation has occurred a sufficient distance from the pylorus and the induration about is not too great, inversion of the perforated area is desirable. When inversion will likely result in obstruction of the pylorus, or the surrounding induration makes such a procedure impractical, approximation of the edges of the perforation by chromic sutures covered over by one or more layers of omentum and at times the round ligament suffices to take care of the situation. At times when the ulcer is small and situated at or very near the pylorus, it may be excised by including it in a pyloroplasty incision. This has the advantage of

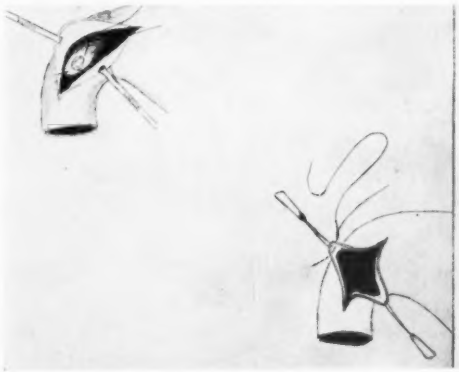

FIG. 4.—Showing method of controlling hemorrhage from duodenal ulcer on posterior wall and conversion of incision into pyloroplasty.

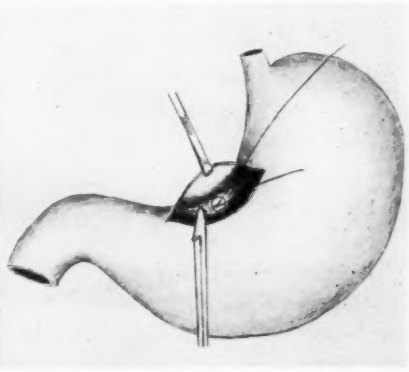

FIG. 5.—One method of controlling bleeding from ulcer on posterior wall of lesser curvature of stomach.

not only caring for the existing emergency but at the same time contributes so definitely toward prevention of further symptoms as to justify its use in selected cases.

Unless the perforation has been of sufficient duration to produce walled off areas with the development of abscess pockets the institution of drainage is of doubtful value. Cleansing of the abdominal cavity of food particles and sucking out of the accumulated exudate is sufficient. Drainage will not prevent an impending peritonitis and collections of pus can be drained to better advantage if and when they occur. Whenever drainage seems indicated it is important to use only rubber tissue and to be certain that it does not come in close proximity to the region of the perforation. Some individuals are apparently cured by the ulcer perforating but the percentage I believe is comparatively small. One case survived the closure of his first perforation but succumbed from the second catastrophe two years later.

The proper handling of the bleeding gastric or duodenal ulcer at times taxes the best judgment of both internist and surgeon. It has been the experience of the majority of observers that such cases will clear up by conservative measures. Persistence in this faith at times reduces the indi-

vidual to such a state that he will not survive operative interference, and medical treatment proves futile. It has been our experience that repeated blood transfusions are often life saving and we do not in the slightest degree subscribe to the idea that transfusions raise the blood pressure and are likely to do more harm by blowing out the clot than they are likely to do good. If operation is decided upon, a cannula tied into a vein with a battery of immediately available donors to be used before, during and after operation is a set up that is indispensable.

If possible, it is extremely desirable to tide the patient over the acutely bleeding period, for if it becomes necessary to subject him to surgery because of hemorrhage only the most conservative procedure that will arrest the hemorrhage is permissible. Rarely will this be of a curative nature. If the bleeding is from a duodenal ulcer it usually is situated on the posterior wall. It may be necessary to approach the ulcer by opening the duodenum ligating the bleeding vessel from within or by placing sutures about its base from without or by a combination of both. The incision may be prolonged across the pylorus into the stomach and converted into a pyloroplasty. If the hemorrhage is from a gastric ulcer, plunging a cautery through its base with suturing of the opening reinforced by a patch of omentum may suffice. In case the ulcer lies on the posterior wall and the gastrohepatic ligament above is thick and edematous, and the ulcer not easily approached by this route, an opening in the anterior wall will permit of suture or cauterization and suture from within.

Each situation must be dealt with as found, always remembering that the object of the operation is to control the bleeding point in the most conservative manner possible. It is also to be remembered when the bleeding is from the duodenum that the demonstration of an ulcer may not always be possible. Duodenitis as pointed out recently by Westermann[6] may give rise to severe bleeding and the short circuiting of the outflow of gastric contents around the involved area is the only method of approach that offers much opportunity for cure.

SUMMARY.—(1) Duodenal ulcer is a medical problem unless complications arise.

(2) Gastric ulcer is a surgical problem unless quickly responding to medical treatment.

(3) Gastric carcinoma by whom and by what method treated reflects little if any glory on medical progress.

(4) Duodenal ulcers when subjected to surgery may be treated conservatively in selected cases but give the best end-results after subtotal resection.

(5) Subtotal resection is the method of choice in the surgical treatment of gastric ulcers.

(6) Pyloric exclusion has given excellent results in selected cases and probably is deserving of more attention than it has received in the past.

(7) In gastroduodenal perforations and hemorrhage only sufficient interference to care for the existing emergency is justifiable.

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# PERITONITIS AS A FACTOR IN THE MORTALITY OF GASTRO-INTESTINAL SURGERY

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THE observation that peritonitis is a frequent cause of death following operations upon the gastro-intestinal tract has led to the assumption that the contamination of the peritoneal surfaces with intestinal contents during the operative procedure is responsible for this peritonitis. As a result, we find that the measures to prevent this fatal peritonitis have consisted in first, the proposal of the various more or less complicated "aseptic" methods of anastomosis, and secondly, in peritoneal vaccination to increase the resistance of the peritoneum to this slight contamination. There are certain considerations, however, which question operative soiling as the important cause of fatal peritonitis. The natural defensive powers of the peritoneum in experimental animals[1] are sufficiently great to withstand a definite and considerable inoculation with bacteria, except those of great virulence, providing this inoculation is not a prolonged feeding-in of organisms as from a suppurative focus or from an opening into the lumen of the bowel. That the peritoneum in man is probably almost equally resistant is evidenced by the frequent prompt recovery from peritonitis after the surgical removal of a gangrenous appendix. In addition, we have the clinical observation that there is frequently more or less unavoidable soiling when the bowel is opened at operation, and yet fatal peritonitis is the exception in such cases rather than the rule.

The study which forms the basis for this communication was undertaken to determine the relative importance of peritonitis as a cause of death following operative procedures upon various parts of the gastro-intestinal tract, and to investigate the cause of the peritonitis in these fatal cases. The deaths following gastro-intestinal surgery at the Peter Bent Brigham Hospital from 1913 to the present time were analyzed, including in this study only those which were submitted to postmortem examination. Fatalities after simple exploratory laparotomy were excluded, as well as cases in which peritonitis was found to be already present at operation or where the operation was undertaken for a primarily inflammatory condition. A total of 91 cases were thus available for study. Of this number, 23 or one-fourth died of peritonitis. The findings were as follows:

GASTRIC SURGERY.—There were 25 autopsied fatalities and in these the operative procedure had been gastric resection in 13 cases, gastrojejunostomy in nine cases, gastrojejunostomy with pyloroplasty in three cases, and gastrostomy in one case. In eight patients the operation had been undertaken

for peptic ulcer and in the remaining 17 for carcinoma of the stomach. The causes of death are detailed in Table I.

TABLE I

CAUSES OF DEATH IN 25 CASES OF GASTRIC SURGERY

| | |
|---|---|
| Pneumonia | 8 cases |
| Circulatory failure | 4 cases |
| Pulmonary abscess | 3 cases |
| Pulmonary embolus | 2 cases |
| Obstruction | 1 case |
| Hemorrhage | 1 case |
| Duodenal fistula | 1 case |
| Septicemia (from hypodermoclysis) | 1 case |
| Peritonitis | 4 cases (16 per cent) |
| Total | 25 |

Closer inquiry into the four instances of fatal peritonitis reveals the following:

**Case S. 18417.**—Male, aged 51. Gastric resection, Billroth I, for carcinoma. Died in five days. Autopsy showed bronchopneumonia with generalized peritonitis due to perforation of the anastomosis.

**Case S. 28192.**—Female, aged 35. Excision of pylorus and posterior gastrojejunostomy for duodenal ulcer. Died in 13 days. Autopsy showed generalized peritonitis. The anastomosis was open, partially walled off by fresh adhesions.

**Case S. 12135.**—Female, aged 47. Gastric resection, Billroth II, for carcinoma. Jejunostomy four days later for obstruction. Died 14 days later. Autopsy showed bronchopneumonia and peritonitis with leakage at the anastomosis apparently due to tension by too short a loop of jejunum.

**Case S. 38016.**—Male, aged 73. Posterior gastrojejunostomy for carcinoma. Died in eight days. Autopsy showed bronchopneumonia and generalized peritonitis without any definite focus.

SMALL BOWEL SURGERY.—There were 14 autopsied fatalities. In nine of these the operative procedure was resection, in five enterostomy, and in one enterotomy. In every instance surgery had been undertaken because of intestinal obstruction. In eight patients the obstruction was caused by a strangulated hernia, in three by adhesions, and in the remaining three by carcinoma, mesenteric thrombosis and impacted gallstone, respectively. In all of these patients the physiologic depletions associated with the obstructive condition doubtless played a more or less important part in the fatal outcome;

TABLE II

CAUSES OF DEATH IN 14 CASES OF SMALL BOWEL SURGERY

| | |
|---|---|
| Pneumonia | 7 cases |
| Circulatory failure | 4 cases |
| Parotitis | 1 case |
| Peritonitis | 2 cases (14 per cent) |
| Total | 14 |

aside from this factor the causes of death as disclosed at autopsy are detailed in Table II.

Both instances of peritonitis occurred in the resection group, the circumstances being as follows:

**Case S. 30073.**—Male, aged 59. Resection of ileum and end-to-end anastomosis for strangulated femoral hernia of two days' duration. Died in nine days. Autopsy showed generalized peritonitis. The margins of the stoma were gangrenous due to impaired blood supply.

**Case S. 21876.**—Female, aged 66. Strangulated femoral hernia of five days' duration. Resection of gangrenous ileum by a modified Mikulicz procedure. Considerable fecal leakage at operation. Died the following day. Autopsy showed generalized peritonitis without any definite focus.

Large Bowel Surgery.—There were 52 autopsied fatalities. In 48 of these the operation had been undertaken for carcinoma, distributed as follows: proximal colon nine cases, transverse colon two cases, distal colon 18 cases, rectum and rectosigmoid 19 cases. In the remaining four patients operation was for relief of obstruction due respectively to volvulus, hernia, adhesions and anal stricture. The operative procedure was confined to colostomy in 20 instances. The causes of death are detailed in Table III.

Table III

CAUSES OF DEATH IN 52 CASES OF LARGE BOWEL SURGERY

| | |
|---|---|
| Pneumonia | 19 cases |
| Circulatory failure | 9 cases |
| Intestinal obstruction | 4 cases |
| Pelvic cellulitis and septicemia | 2 cases |
| Pulmonary embolism | 1 case |
| Peritonitis | 17 cases (33 per cent) |
| Total | 52 |

Four of the cases of peritonitis followed simple colostomy:

**Case S. 3627.**—Male, aged 53. End type sigmoidostomy for inoperable carcinoma of the sigmoid. Died in three days. Autopsy showed a perforation of the bowel wall through the carcinoma and a large pelvic abscess.

**Case S. 29532.**—Male, aged 74. End type sigmoidostomy for carcinoma of the rectum. Died in two days. Autopsy showed bronchopneumonia with peritonitis from wound infection and necrosis of the abdominal wall.

**Case S. 42748.**—Male, aged 71. Transverse loop type colostomy for carcinoma of the splenic flexure. Died the following day. Autopsy showed generalized peritonitis with a perforation of the bowel through the carcinoma.

**Case S. 26006.**—Male, aged 51. Cecostomy for carcinoma of the sigmoid. Gross fecal contamination at operation. Died in seven days. Autopsy showed generalized peritonitis with no definite focus.

The remaining 13 instances of fatal peritonitis followed more extensive procedures. In this group there were six cases in which the peritonitis was caused by a defect in the bowel wall.

**Case S. 18917.**—Female, aged 55. Side tracking ileosigmoidostomy for carcinoma of the transverse colon. Died in ten days. Autopsy showed generalized peritonitis with a perforation of the colon through the tumor.

**Case S. 22003.**—Male, aged 71. Transverse colostomy followed in two days by resection of sigmoid for volvulus and removal of a congested appendix. Died in nine days. Autopsy showed generalized peritonitis. The appendix stump was open.

**Case S. 16555.**—Male, aged 48. Resection of carcinoma of the splenic flexure with end-to-end anastomosis and cecostomy. Died the following day. Autopsy showed generalized peritonitis. The Mixter tube had torn out of the cecum and the contents were flowing out freely into the peritoneal cavity.

**Case S. 48382.**—Male, aged 32. Side tracking ileotransverse colostomy for carcinoma of the cecum. Died in seven days. Autopsy showed generalized peritonitis. Both the anastomosis and the distal stump of ileum had opened.

**Case S. 26063.**—Male, aged 73. Cecostomy followed in 18 days by resection of carcinoma of the sigmoid and end-to-end anastomosis. Died in five days. Autopsy showed generalized peritonitis. The sutures had given way at two points allowing fecal extrusion.

**Case S. 31188.**—Female, aged 38. Resection of carcinoma of the sigmoid by a modified Mikulicz procedure. Died in three days. Autopsy showed generalized peritonitis. There was a perforation 3 Mm. in diameter in the proximal limb, due apparently to a slough caused by a suture tacking a fat tab to the bowel wall.

There were four cases caused by a septic focus due to vascular interference.

**Case S. 39526.**—Male, aged 69. Cecostomy followed in seven days by resection of carcinoma of the splenic flexure by a modified Mikulicz procedure. Died in seven days. Autopsy showed generalized peritonitis and lobar pneumonia. The distal limb of sigmoid was gangrenous.

**Case S. 12654.**—Female, aged 59. First stage of abdominoperineal operation for carcinoma of the rectum. Stump of sigmoid turned down into pelvis. Died in four days. Autopsy showed generalized peritonitis and bronchopneumonia. The sigmoid stump was gangrenous and the reconstructed pelvic floor had sloughed.

**Case S. 42526.**—Male, aged 65. First stage of abdominoperineal operation for carcinoma of the rectum. Stump of sigmoid turned down into pelvis. Died in five days. Autopsy showed generalized peritonitis and bronchopneumonia. The sigmoid stump was gangrenous and pus was flowing up through a leak in the reconstructed pelvic floor.

**Case S. 22780.**—Male, aged 68. Abdominoperineal resection for carcinoma of the rectosigmoid. Died in five days. Autopsy showed bronchopneumonia and generalized peritonitis. The reconstructed pelvic floor had sloughed, allowing purulent contamination from the posterior wound.

In two instances operation was performed through a septic field.

**Case S. 38593.**—Male, aged 45. Ileotransverse colostomy followed in 11 days by resection of carcinoma of the hepatic flexure. The growth was incompletely removed and necrotic purulent tissue was broken into during the procedure. Died in six days. Autopsy showed generalized peritonitis. Anastomosis was intact and there was no definite focus.

**Case S. 30774.**—Female, aged 31. Resection of extensive carcinoma of the transverse colon involving a loop of ileum and the sigmoid. Operation was performed through the septic field of a fecal fistula resulting from an exploratory operation six weeks previously. End-to-end repair of ileum and sigmoid; Mikulicz procedure to transverse colon. Autopsy showed generalized peritonitis with a necrotic abscessed area in the region of the Mikulicz colostomy.

In one instance fecal contamination at operation was apparently responsible.

**Case S. 28636.**—Male, aged 60. Resection of carcinoma of sigmoid with end type sigmoidostomy. Operator's note mentions considerable fecal soiling due to slipping clamp. Died in six days. Autopsy showed a generalized peritonitis with no definite focus.

COMMENT.—It is interesting to note that the most important cause of death after operations on the gastro-intestinal tract proved to be pneumonia and not peritonitis. This was true even in the case of large bowel surgery. Therefore, in endeavoring to lower the mortality in this group of patients it is apparent that measures to prevent postoperative pneumonia are of equal or greater importance than are efforts to prevent peritonitis. Such measures would include avoidance of surgery in the presence of acute upper respiratory infections, sitting the patient up in bed after operation, turning him frequently, getting him out of bed as soon as possible, prompt control of abdominal distention, cardiovascular stimulation when indicated, and possibly hyperventilation by means of carbon dioxide inhalations.

A study of the postmortem findings in the 23 cases of fatal peritonitis reveals the significant fact that in all but six cases there was found a definite focus of contamination. This focus proved to be a grossly leaking anastomosis in five cases, a perforation through a carcinoma in three cases, and a fecal leak in three other cases, due, respectively, to an open appendiceal stump, the slough caused by a tight suture, and the tearing out of a cecostomy tube. In five cases the infective focus was gangrenous bowel caused by impaired blood supply, and in one case the focus was a fulminating wound infection involving all layers of the abdominal wall.

In only six instances, therefore, could the fatal peritonitis be attributed to contamination of the peritoneal surfaces at operation. In two of these six cases the operator mentions in his note that there was gross soiling with feces by the unexpected slipping of a clamp. In one instance the operation was performed through a septic field caused by a fecal fistula, and in another the peritoneum was grossly contaminated by breaking into foul necrotic cancerous tissue. There are left, then, only two instances in which, following an uncomplicated operation on the stomach or bowel, the patient died of peritonitis which could be fairly attributed to the slight unavoidable peritoneal contamination involved in these procedures.

The five cases in which the cause of the fatal outcome was a leaking anastomosis deserve closer scrutiny. The interval between operation and the clinical manifestation of peritonitis was in two cases three days, in one case five days, and in two cases eight days. Death occurred two to six days later. In four of the five cases the anastomosis was made with chromic catgut, used as continuous sutures of size number one; a first through and through and a second sero-serous. In the fifth case a gastroduodenal anastomosis had been reinforced anteriorly with interrupted silk sutures. The defect in the suture line found at autopsy, however, was situated on the

posterior aspect of the anastomosis. It seems reasonable, therefore, to believe that the use of non-absorbable sutures, at least in the outer row of stitches, might have prevented the leak in some of these cases.

## CONCLUSIONS

(1) Peritonitis accounts for about one-fourth of the fatalities of gastro-intestinal surgery.

(2) The incidence of fatal peritonitis after operations on the large bowel is about twice that following operations on the stomach or small bowel.

(3) Pneumonia is a more frequent fatal complication than peritonitis, accounting for over one-third of the fatalities.

(4) The resistance of the human peritoneum to a bacterial contamination is great. Operative fecal soiling, unless massive, rarely causes fatal peritonitis.

(5) Of the cases of fatal peritonitis studied, only one-fourth could be attributed to operative soiling. The rest were due to gross leakage resulting from a defective anastomosis or from perforation elsewhere, to gangrene resulting from impaired blood supply, or to a suppurative focus in the wound or retroperitoneum.

(6) In the prevention of fatal postoperative peritonitis, accurate suturing with careful attention to blood supply is of greater importance than strict asepsis.

(7) The elaborate methods of anastomosis which emphasize speed and asepsis may prove to be less safe than the more simple and precise methods.

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# INDUCED AND SPONTANEOUS CHANGES IN BLOOD AMYLASE PARTICULARLY IN RELATIONSHIP TO THE PANCREAS

## AN EXPERIMENTAL STUDY

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IT IS generally conceded that the pancreas exerts a profound influence upon the amylolytic potence of the blood serum, and that following experimental occlusion of the pancreatic ducts there is a sharp increase in potence followed by a decline to approximately normal or even subnormal values. The effects of pancreatectomy, however, have been a subject of controversy; and, although most recent investigators have reported an immediate postoperative decrease in serum amylolytic power, there is disagreement as to whether or not a return to normal occurs in animals treated with insulin.

The immediate effects of experimental occlusion of the pancreatic ducts were reported in 1908 by Schlesinger.[1] These results have since been confirmed. A twentyfold rise in serum amylolytic potence following duct ligation is not uncommon. In the recent investigations of Elman, Arneson and Graham,[2] Johnson and Wies,[3] and others[4,5] a regression toward normal values, occupying several weeks, has been demonstrated. Schlesinger[1] studied also the effects of pancreatectomy, and observed in two dogs and one cat a prompt postoperative diminution in potence of serum diastase. Most other investigators have had similar results, but several[6,7,8,9] have reported no change or an increase. The literature has been reviewed by Elman and his collaborators[2] and by McCaughan.[5] In some of the early experiments however, it is doubtful that complete pancreatectomy was effected; and the reported spontaneous recoveries reflect laxity in this regard. A small fragment with obstructed ducts, inadvertently left behind at operation, might easily obscure any influence attributable to removal of the major portion of the gland. Furthermore, if the ducts are ligated early in the course of total pancreatectomy, there may be considerable backing up of amylase into the blood and lymph channels before removal of the gland is completed. Indeed, a fourfold increase in serum amylase may occur in dogs within 15 minutes after obstruction of the ducts.[2] Quite apart from these considerations, the weight of evidence indicates that pancreatectomy in dogs induces a prompt decline to approximately one-half or one-third the preoperative level.

Since the development of insulin therapy, it has been possible to maintain depancreatized animals alive and in good condition for long periods of time. Markowitz and Hough[10] tested the serum amylolytic power in dogs which had been so maintained for several months, and reported normal values;

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whereas, in other experiments, they found characteristically decreased potence soon after pancreatectomy. They stated further that injection of insulin affected the blood diastases but slightly and in a variable manner. Reid, Quigley and Myers[11] reported likewise a postoperative decline soon followed by a rise to or above the preoperative level when diabetes was controlled by administration of insulin; but claimed that lapse in treatment induced a reduction in blood diastase, with a subsequent return to normal when insulin injections were resumed. On the other hand, Zucker, Newburger and Berg[4] reported that in depancreatized dogs treated with insulin the serum amylolytic potence fell to less than half the preoperative level and did not recover. They estimated potence by means of a modification of Wohlgemuth's method, and made the interesting observation that the measured effect was less and inconstant when glycogen was used as substrate instead of starch.

This emphasized an urgent need of more critical examination of the methods employed to estimate amylolytic potence. The Wohlgemuth and the much more precise viscosimetric methods may be considered to reflect chiefly action upon $\alpha$-amylose, the first stage in a cascade of reactions ending in sugar formation. On the other hand, the achromatic iodine methods measure a combined enzymic effect upon amyloses and erythrodextrins,[12] whereas those based on sugar formation may be influenced by enzymes affecting any stage or stages in the cascade. Indeed, some of these enzymes may act not at all upon the early stages of starch degradation, and have little claim to the name, *amylase*. Such an enzyme was found in malt extract by Wijsman[13] in 1889, and Giesberger[14] has claimed that a similar enzyme (so called *$\beta$-amylase*) occurs in pancreatin and in saliva. Under certain conditions, such an enzyme may be the pace-setter, or chief determinant of reaction speed. We do not wish to raise objection to all uses of technics based on sugar formation, but merely to indicate a possible source of some discrepancies, since Markowitz and Hough,[10] and Reid, Quigley and Myers,[11] who employed such methods, are in disagreement with Zucker, Newburger and Berg,[4] who did not. It is not at all certain that these investigators were measuring activity of the same enzyme; nor, indeed, that any of them were concerned throughout their experiments with a single enzyme or mixture in fixed proportions. From this point of view we have examined a precise viscosimetric method for estimation of amylolytic activity, which had been described previously[15, 16]; and have shown[17] that, measured in this way, the amylolytic potence of the serum of normal and of depancreatized dogs as well as that of dog pancreatic extract is attributable to one and the same chemical individual. Similarly,[17] in the case of humans, one and the same chemical individual appears to be responsible for the amylolytic potence of serum, pancreatic extract, and saliva; although human, dog and hog amylases are readily distinguishable from each other.

In recent years a considerable literature has appeared in regard to the clinical value of serum amylase determinations in the diagnosis of human pancreatic disease. Normal variation has been explored, and it has been

shown[2, 18, 19] that exceedingly high values are found consistently in acute pancreatitis. However, in chronic pancreatic disease normal values of serum amylase are encountered so frequently as to render the test of little value in such cases. Thus, in patients with carcinoma of the head of the pancreas, where progressive occlusion of the ducts is accompanied by progressive diminution of functioning acinar tissue, the concentration of serum amylase may be normal. The published clinical reports have largely been confined to single observations on any given individual.

It would seem preferable to study spontaneous variations in serum amylolytic potence with time; or, better still, to induce modification of pancreatic function and study consequent variations in potence. This would be analogous to the familiar use of histamine in gastric analysis. A possible basis for such a test in the case of the pancreas is suggested by the observations of Anrep[20, 21] and Korovitsky,[22] who indicated in acute experiments with dogs and cats that stimulation of the vagus may produce spasm of the pancreatic ducts as well as increased pancreatic secretion. Either or both of these mechanisms might induce a rise in serum amylolytic potence, and the character of the perturbation might furnish an indication of the functional ability of the pancreas. A prospective pharmaceutic means to this end was suggested by the well-known fact that the physiologic action of acetylcholine and some of its derivatives simulates that of widespread parasympathetic stimulation. Furthermore, Antopol, Schifrin and Tuchman[23] found that injection of acetyl $\beta$-methylcholine chloride in normal dogs resulted in a prompt rise in serum amylolytic potence, and that the response could be inhibited by a preliminary injection of atropine or enhanced by eserine (physostigmine). The rôle of the latter as a protector of acetylcholine from physiologic destruction has been demonstrated in the experiments of Engelhart and Loewi.[24] Antopol and his collaborators did not suggest in their report that the rise in serum amylolytic potence reflects chiefly a pancreatic response. However, this seemed to us not at all unlikely, and confirmed us in our opinion that the possibilities of utilizing such means as an indicator of the functional ability of the pancreas should be investigated.

Accordingly, experiments were designed to bring evidence to bear on this question, and to elucidate the rôle of the pancreas in control of serum amylase concentration. The object of the present communication is to report the results of these investigations.

*Technic in Experimental Research.*—Amylolytic potence was measured by means of the viscosimetric technic[15, 16] to which reference has been made. This is a method of high precision, with an estimated error in most instances less than 1.5 per cent. An arbitrary unit of amylase concentration based on potence under reproducible conditions has been developed[25, 26] for hog pancreatin (Parke, Davis). The concentration of human serum amylase may be expressed conveniently in terms of an equivalence[15, 17] which persists throughout the pH range investigated (5.1, 6.7). However, with dog serum amylase an equivalence established at one pH in this range would not

be valid at another.[17, 27] Accordingly, we have adopted a unit for dog amylase concentration such that, under the conditions of measurement with the substrate, $S_{55}$, previously described,[15, 16] equal concentrations of dog and hog pancreatic amylases have the same activity.[28] As in previous communications, we shall represent amylase concentration by Q, $Q_s$ denoting the serum amylase concentration.

Dogs weighing about 15 to 20 Kg. and in apparently good health were selected for the experimental work, and were kept in clean, well lighted and ventilated, individual cages. Unless otherwise stated, the dogs were fed once daily, and normal animals were given a diet consisting chiefly of dog biscuit, with occasional bones, meat, milk and yeast. Other diets will be described in connection with individual experiments. Although there is reason to believe that in dogs so maintained little or no fluctuation in $Q_s$ is to be associated with feeding, blood samples were taken not sooner than 12 hours after meals or insulin injection, except in special experiments where this was not feasible because of the frequent sampling required. For estimation of $Q_s$, about five milliliters of blood were drawn aseptically from a leg vein and allowed to stand at room temperature for a half hour in a rubber[29] stoppered centrifuge tube. This was then placed in a refrigerator for one-half to 16 hours, the clots broken, the capped tubes centrifuged at high speed for 20 minutes, and the serum decanted and stored in a refrigerator until used. Under these conditions serum may usually be kept for several days without much change in $Q_s$, but estimations were made on the same or following day in the large majority of instances.

Anesthesia for surgical operations was induced by intraperitoneal administration of sodium amytal in doses approximating 0.06 Gm. per Kg. of body weight.

*Effects of Pancreatectomy on Serum Amylase Concentration.*—After a short period of preliminary observation, the effects of pancreatectomy upon $Q_s$ were observed in several experiments. During the course of excision of the gland particular care was taken to insure complete removal, and yet to avoid injury to the pancreatic ducts until the organ had been freed at all other points. The ducts were then ligated and severed, and the gland removed. Immediately after operation the animals were given 10 units of insulin, followed by hypodermoclysis or intravenous infusion of 500 Ml. of 5 per cent glucose in physiologic saline. A blood sample was taken just before operation but not again until the next day. The daily diet after operation consisted of about 500 Gm. of canned horse meat (Chappel Bros.), 200 to 300 Gm. of dog biscuit, 5 Gm. of brewers' yeast, 2 Gm. of pancreatin, and small amounts of lecithin. Administration of these latter preparations has been discussed in a recent article by Ivy.[30] Twenty to 30 units of insulin was given before feeding, and water was allowed ad lib. During the first postoperative day several small feedings were administered, each preceded by injection of five to ten units of insulin. Thereafter the amounts of food and insulin were adapted to the individual needs of animals. Occasionally,

fresh meat was substituted for the canned product; and, during certain periods to which reference will be made below, pancreatin was omitted from the diet in order to ascertain whether or not an appreciable effect on $Q_s$ might be manifested. Under this regimen, animals were maintained in fairly good condition although the urine was not kept sugar free.

Results thus obtained with three normal dogs (Nos. 1, 2, and 3) subjected to pancreatectomy are presented in Chart 1.

In each instance there was a sharp decline in $Q_s$, apparent as early as the first postoperative day. For comparison, three levels, M, A, and B, are

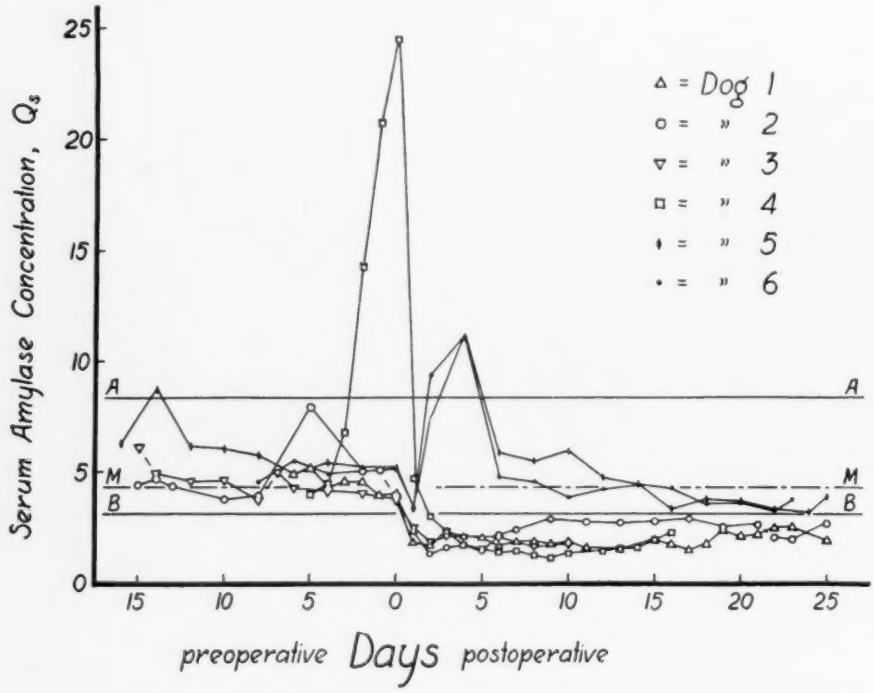


CHART 1.—Effects on $Q_s$ of pancreatectomy (Dogs 1, 2, 3 and 4) and of formation of gastric pouch (Dogs 5 and 6). M is the median of observed normal values, 5 per cent of which lay above A and an equal number below B.

given representing statistics obtained from 144 observations on 13 presumably normal dogs.[31] These observations lay in equal numbers above and below the level M, the median (4.26), whereas only 5 per cent lay above A and an equal number below B. In presumably normal animals there were occasional large spontaneous excursions above the median value. These were usually characterized by a gradual rise in $Q_s$ occupying several days, and a return to normal which was almost a mirror image of the rise. The similarity of this picture and that found in cases of acute pancreatitis or obstruction of the pancreatic ducts suggested that the observed spontaneous perturbations reflect mild and transient disturbances of like nature. With this in mind, a close watch was kept for such excursions. The most extensive in our experience occurred in Dog 4; and, at a time when the serum amylase was still

rising, pancreatectomy was performed. This initiated a precipitate decline in $Q_s$ (Chart 1). Except for the value obtained in this animal on the first day after operation, all observations on depancreatized dogs recorded in the chart lie below the level B, whereas only 5 per cent of the values for normal dogs do.

The pancreas of Dog 4 appeared normal in gross at the time of operation. From various portions of the excised gland six histologic sections were made, three of which—from the proximal portion of the head and an adjacent part of the body—revealed on microscopic examination a few minute areas of necrosis. The most striking lesions involved the interstitial adipose and connective tissues, and presented a characteristic aspect of fat necrosis. In the middle of such a lesion (Fig. 1) the adipose tissue cells were replaced by an amorphous, pink-stained mass, which was surrounded by a fairly

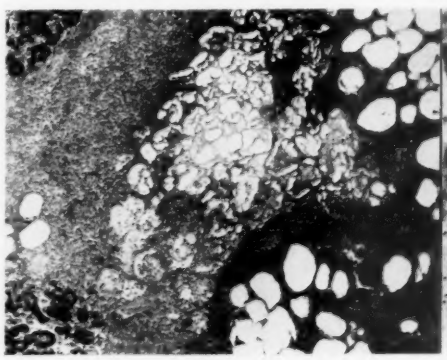

FIG. 1.—Photomicrograph of a region of fat necrosis which occurred spontaneously in the pancreas of Dog 4.

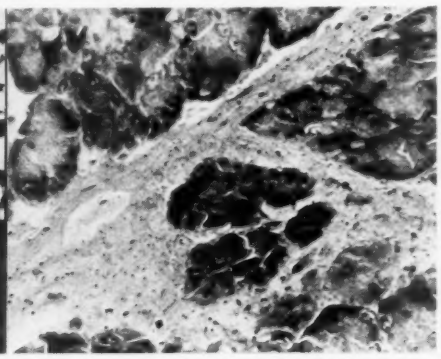

FIG. 2.—Photomicrograph showing contiguous acinar and septal necrosis in the pancreas of Dog 4 in contrast with normal acinar tissue in the upper left corner.

dense cellular zone of infiltration, composed chiefly of polymorphonuclear leukocytes and small round cells. Many of the nuclei were pycnotic and some were fragmented. There were a few young fibroblasts at the periphery of the lesion. Some lesions were found in portions of the interlobular septa where little or no adipose tissue occurred; and were characterized by a granular, semi-opaque appearance, with loss of cellular outline, scattered nuclear fragments and basophilic stippling. A connection of necrotic tissue could frequently be traced through the septa between fairly remote lesions, which indicates that necrosis had probably spread along the interstitial tissues. Evidence of early necrosis was observed in some of the acini, but only in lesions adjoining necrotic septa. The acinar lesions were well defined in only one section, and were characterized by shrunken and fragmented cells with pycnotic nuclei and deeply stained basophilic cytoplasm (Fig. 2).

On the whole, there was a remarkable paucity of parenchymatous involvement. The insular tissue and pancreatic ducts were normal in appearance throughout, and the latter contained little or no débris. All the sections

revealed diffuse interstitial edema and subcapsular hemorrhage which, however, might have been the result of trauma during excision of the gland.

Several days after operation this dog developed rhinitis and conjunctivitis, and within a week had unmistakable signs of distemper. It would seem probable in retrospect, that the animal was in the invasive stage of the disease at the time of operation. Thus a question arises as to the possible etiologic rôle of distemper in production of the pancreatitis. Although nodular fat necrosis of the pancreas is said[32] to occur in "absolutely normal lobules in fattened pigs" and also exceptionally in the dog where it may produce "no symptoms," the occurrence of lesions such as we have described has apparently not been reported in connection with distemper.[33] As to the spontaneous increase in $Q_*$, we have observed similar but much less extensive perturbations in other presumably normal dogs. Only one of these (Dog 12) developed distemper subsequently, but it is interesting to note that the extent of rise in this case was second only to that observed in Dog 4, and coincided with the invasive stage of the disease. Daily observations on Dog 12 gave the following values of $Q_*$: 3.80, 3.88, 3.81, 3.47, 3.79, 4.84, 5.10, 9.70, 11.48, 9.82, 6.01, 3.95, 4.57, 3.49, 3.55, 3.58.

Dog 4 was sacrificed on the sixteenth postoperative day and no remaining pancreatic fragments were found. Postmortem examination of other dogs subjected to pancreatectomy likewise revealed no pancreatic tissue.

A crude control as to the possible influence of dietary change following pancreatectomy is afforded by observations on Dogs 5 and 6, which for a week preceding operation were placed on the regimen for depancreatized dogs, except that insulin, pancreatin and lecithin were not supplied. In both animals $Q_*$ was close to the normal median throughout this interval. It might be supposed that the decline in $Q_*$ after pancreatectomy in Dogs 1, 2, 3 and 4 is not specifically referable to extirpation of the pancreas, but might follow any extensive operation which interferes with the animal's nutrition. In order to furnish some control in this regard, Dogs 5 and 6 were subjected to the formation of gastric pouches. In one instance (Dog 5) a pyloric pouch was made, and in the other a pouch including portions of both pyloris and antrum. Immediately thereafter these dogs were fed milk until they would again accept the preoperative diet, which was thereupon substituted. Effects on $Q_*$, represented in the same figure, offer a considerable contrast with those for depancreatized animals.

As mentioned in the introduction, a difference of opinion is expressed in the literature as to whether or not there is a tendency for serum amylase concentration to return to a normal level after pancreatectomy. Two of our animals were maintained for a period in excess of four months following this operation, and $Q_*$ was measured frequently (Chart 2).

A, B and M have the same significance as before. There is no apparent tendency for the serum amylase concentration to rise to the preoperative level; and, indeed, all observations but one lie below the level B.

Pancreatin was omitted from the diet of Dog 4 during the first six post-

operative days, and from that of Dog 1 before the nineteenth and after the one hundred and thirteenth postoperative days. This did not seem to influence $Q_s$ as may be seen in the first two charts. Several of the dogs there represented were used in special experiments involving subcutaneous injec-

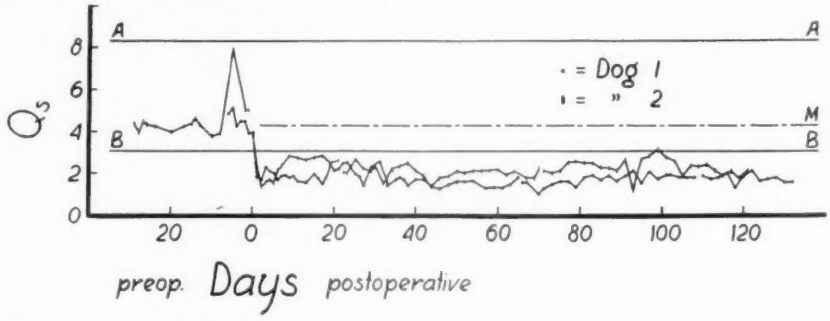


CHART 2.—Extended observations on two depancreatized dogs, showing no return trend of $Q_s$ toward the range (A, B).

tion of acetyl β-methylcholine chloride and eserine sulphate. Observations showing the response to such administration will be presented below, but are omitted from Charts 1 and 2, where a broken line between recorded points indicates such omission. Whatever effects upon $Q_s$ followed injection, they were usually inappreciable after the lapse of a day. Exclusive of the first

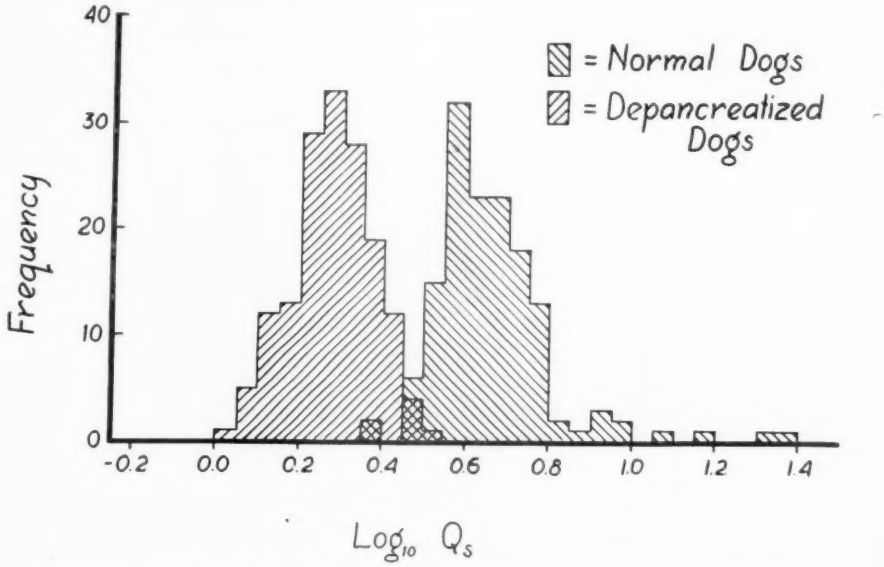


CHART 3.—Frequency-distribution of log $Q_s$ in observations on presumably normal and on depancreatized dogs.

observation made on the day after such injection and those of the intervening period, there were 144 observations on 13 presumably normal dogs, and 157 observations made on four depancreatized dogs after the first postoperative day. Although these groups are not composed of strictly in-

dependent observations, their frequency-distribution diagrams, given in Chart 3 are illuminating.

Log $Q_s$ is used as variate instead of $Q_s$ for convenience in graphic presentation. The median for the normal dogs is appreciably higher than that for the depancreatized animals; and, indeed, the two sets of observations show remarkably little overlap. A tendency in presumably normal dogs to greater spontaneous excursion above the median than below is evident even in the logarithmic graph by the asymmetry of distribution. The absence of such asymmetry in the case of the depancreatized animals sustains the contention that large spontaneous increases in $Q_s$ are the result of pancreatic disturbance.

*Effects of Acetyl β-methylcholine Injection upon Serum Amylase Concentration in Relation to Functional State of the Pancreas.*—As has been mentioned in the introduction, injection of acetyl β-methylcholine in normal dogs may greatly increase the serum amylase concentration. Our first purpose in the following investigations was to ascertain whether or not this response could be definitely related to the pancreas. In all these experiments a standard dose was adopted, which consisted of 0.5 mg. of acetyl β-methylcholine chloride (Merck) per Kg. of body weight and 1 mg. of eserine sulphate (Wyeth) in physiologic saline, administered by subcutaneous injection. $Q_s$ was measured immediately before and frequently for several hours thereafter. The animals were given an extra meal on the preceding night, and were not fed again until approximately six hours after the injection. Results thus obtained with seven normal dogs are represented in Chart 4.

In each instance there was a sharp rise in $Q_s$, although a considerable variation in the extent of the response is apparent. A peak was attained within a few hours, and within a day's time most of the increment in $Q_s$ was spent. One of these dogs (No. 2) was later subjected to pancreatectomy, and the injection was repeated on the twenty-first and seventieth postoperative days. The lack of response, illustrated in the same chart, contrasts strikingly with the normal reaction of the same and other dogs. That this cannot be attributed solely to a developed tolerance is indicated by similar results obtained with another depancreatized dog (No. 1 in Chart 4) which had not received such treatment preoperatively. This animal was injected first on the sixty-fifth postoperative day, and gave at successive observations the values of $Q_s$, 1.81 (pre-injection), 1.88, 1.86, 1.85, 1.86, 1.82, 1.76, and (next morning) 1.55. A second injection was given on the one hundred and eighth postoperative day with like results. These experiments indicate the pancreas as the source of the normal response. However, they do not exclude the possibility that a tolerance for the drug is developed, nor that the supply of amylase or its precursors is so depleted by the first response that another of the same magnitude is rendered impossible until after the lapse of a suitable period for recovery. Accordingly, one dog (No. 7) was reinjected after a lapse of four days, and two others (Nos. 3 and 8) after

a week. The results are given in Chart 5 with those of the initial injection included for comparison.

In each instance the second response was less than the first, but these differences are not nearly so striking as that for Dog 2 with pancreatectomy intervening (Chart 4).

Although the pancreas seems definitely implicated in the response, these data furnish no insight as to the relative importance of altered acinar secretion and duct spasm, the two effects of parasympathetic stimulation reported by Anrep[20, 21] and Korovitsky.[22] We sought in the experiments which follow to bring evidence to bear on this question, and to indicate by functional means

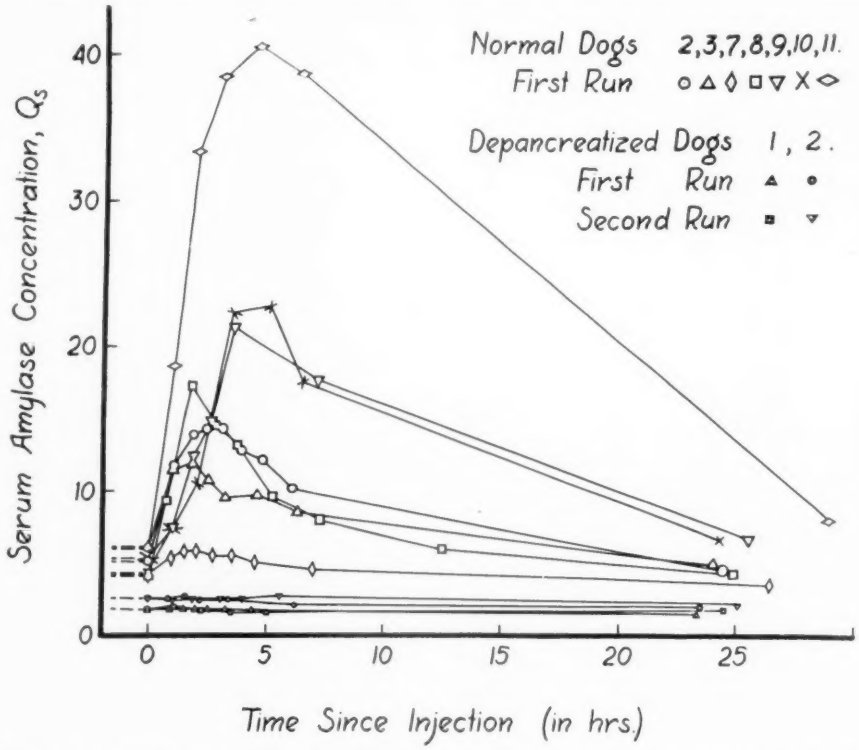


CHART 4.—Comparative response of normal and of depancreatized dogs to standard injection of acetyl β-methylcholine and eserine.

the progress of acinar atrophy even when the serum amylase concentration is not suggestive of abnormality. To this end, two animals (Nos. 10 and 11), which had already been injected once under the standard conditions, were subjected a few days later to ligation of the pancreatic ducts. In each instance portions of the major and minor ducts were excised between ligatures to insure complete and persistent obstruction. After the operation, pancreatin was included in the diet. The serum amylase concentration was observed frequently throughout a period of several weeks, and the response to the standard dose of acetyl β-methylcholine and eserine was observed at various times (Chart 6).

It may be seen that in each dog ligation initiated a characteristic rise in $Q_s$. Dog 11 was reinjected two days after operation, and the further vig-

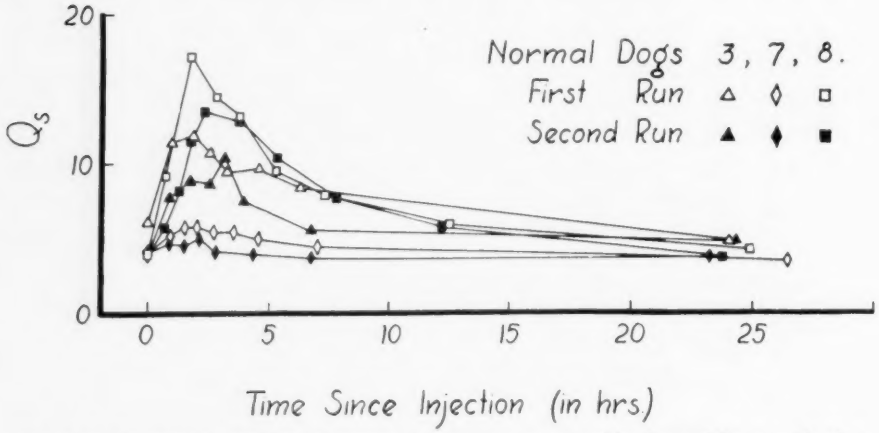


CHART 5.—Comparative response of normal dogs to two separate injections within a week of a standard dose of acetyl β-methylcholine and eserine.

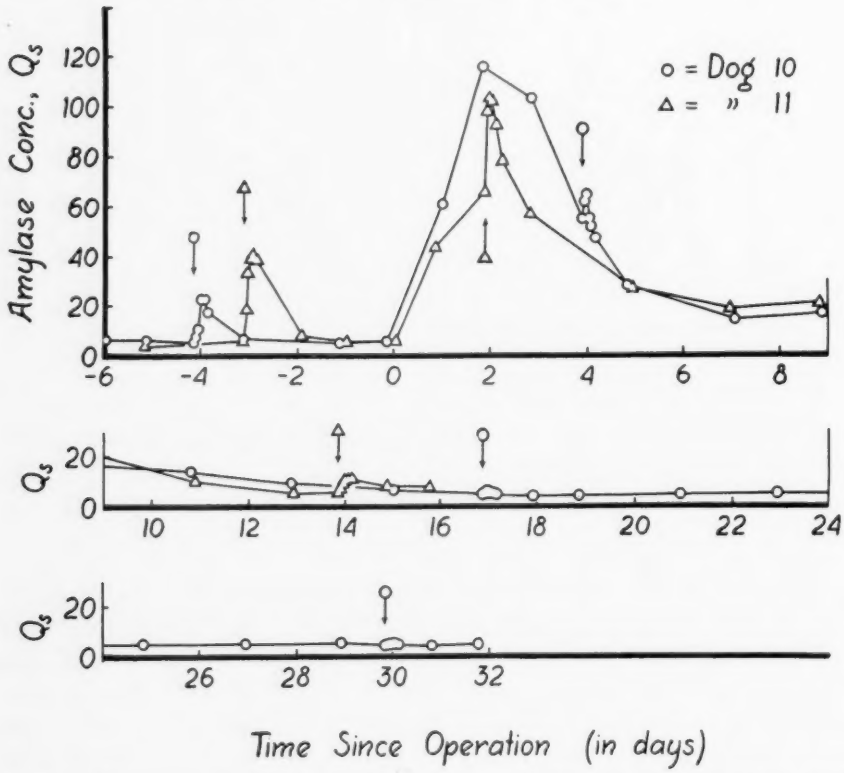


CHART 6.—Response to standard injection of acetyl β-methylcholine and eserine at various times (indicated by arrow) before and after ligation of the pancreatic ducts.

orous response indicates an action on the acinar secretory mechanism, since spasm of already ligated ducts could hardly produce an effect of such mag-

nitude. The reaction of Dog 10 to injection on the fourth postoperative day confirms this, and indicates furthermore that the acinar tissue can still respond after the serum amylase concentration has begun to decline. These effects are in striking contrast with those observed a fortnight or more after duct ligation; and, indeed, it would appear that the response diminishes concomitantly with the progress of acinar atrophy. Thirty days after operation the value of $Q_s$ in Dog 10 was 4.40, approximately the normal median. This was just before a standard administration of acetyl $\beta$-methylcholine, following which the values successively obtained were 4.67, 4.89, 4.90, 5.11, 4.72, and (next morning) 4.47.

At postmortem examination of Dogs 10 and 11, the pancreas in each case was pale, shrunken and firm. Microscopic examination revealed diffuse fibrosis and acinar atrophy, more advanced in the case of Dog 10.

Discussion.—In experiments in which animals were repeatedly injected with acetyl $\beta$-methylcholine and eserine in order to study immediate and remote effects of various operative procedures, it seemed that striking decreases in response could hardly be attributed solely to developed tolerance. As is well known, such medication induces many effects other than that upon serum amylase concentration; clinically striking among which are increased salivation and evidences of gastro-intestinal hyperactivity, such as borborygmi, retching, vomiting and defecation. Judged by the severity of these reactions, the dogs do not appear to develop an appreciable tolerance; but, after one injection, depletion of amylase supplies in the pancreas may temporarily diminish its ability to respond again. The results of experiments wherein normal dogs were injected twice within a week (Chart 5) may be interpreted in this way, but not with great confidence on the basis of these data alone.[34] In any event, considerably greater differences were found in the tests interpreted to indicate pancreatic acinar hypofunction, and in these instances much longer periods were permitted for recovery from preceding injections. Such was the case with the animals whose ducts were ligated, the response to the drug injection a fortnight or more after operation being strikingly less than that observed preoperatively. The simple measurement of $Q_s$ at these same times exhibited little difference, and gave no indication of the extensive postoperative atrophy. Supply of serum amylase by extrapancreatic sources, whatever these may be, seems unaffected by administration of acetyl $\beta$-methylcholine and eserine, and this test furnishes a far more specific indication of pancreatic acinar hypofunction than does the simple measurement of serum amylase concentration. Response to the drug appears to result at least in part from increased rate of release of amylase by the acinar tissue. However, our data do not indicate whether or not the rate of amylase formation is affected, nor how important the rôle of duct spasm may be in production of the response observed in normal animals.

We have called attention to the sporadic occurrence in presumably normal dogs of extensive spontaneous rises in $Q_s$; and have indicated that these are referable to the pancreas, since they were not observed in depancreatized

animals. It may be supposed, in the light of our experience with acetyl β-methylcholine, that these spontaneous perturbations reflect merely functional disturbances attributable to parasympathetic hyperactivity. However, we were able to demonstrate that in at least one instance there was associated structural alteration. This was the case of Dog 4, whose pancreas was removed at a time when the serum amylase concentration had risen spontaneously to an extraordinarily high value. The sharp drop in $Q_s$ thereafter definitely implicated the pancreas; and, although the removed gland appeared normal in gross, histologic examination revealed minute necrotic lesions. It would be rash to assume on the basis of this single observation that such pathologic changes are the usual cause of extensive spontaneous increase in $Q_s$, but we wish to suggest that mild focal pancreatitis, transient and escaping recognition, may occur fairly frequently in the dog. The observed lesions resemble those found in human cases of acute interstitial pancreatitis recently reported by Elman,[35, 36] who noted in several cases so diagnosed a transient elevation of serum amylase concentration. In the patients discussed by Elman abdominal pain was a striking feature, and was characteristically associated with gross swelling or induration of the pancreas. A milder form of this disease, with no conspicuous symptoms, might well account for occasional high values of serum amylolytic potence observed in presumably normal individuals. In 1931, Elman[19] was inclined to attribute such observations made by himself, McCaughan and their co-workers to salivary contamination in pipette technic. However, we[37] have occasionally observed in presumably normal persons values of $Q_s$ about twice the normal mean, under conditions wherein the possibility of salivary contamination could be confidently excluded. The rise in $Q_s$ after a short period of latence which occurred in each of two dogs subjected to formation of gastric pouch is interesting in that Popper[38] has reported similar effects, which he ascribed to transient pancreatitis, after gastric resection in humans. A similar explanation might apply to our dogs.

The results obtained with injection of acetyl β-methylcholine in dogs suggest the application of similar technics to the diagnosis of human pancreatic disease. A few preliminary experiments were made in which moderate doses were injected, unaccompanied by eserine. In some persons a rise in serum amylase concentration ensued, but our observations are too fragmentary to warrant discussion of their significance. It would seem the part of discretion to administer the drug only to patients in whom a diagnosis of acute pancreatitis may be confidently excluded.

## SUMMARY

(1) The concentration of serum amylase, $Q_s$, of normal dogs and those subjected to various experimental procedures was measured by a precise viscosimetric method.

(2) After pancreatectomy there was a sharp decline in $Q_s$ to about one-half the normal median value and no return even after several months.

(3) Occasionally, in presumably normal animals there were extensive spontaneous rises in $Q_s$, which appeared definitely attributable to the pancreas.

(4) The subcutaneous injection of acetyl β-methylcholine chloride with eserine sulphate in normal dogs initiated a prompt rise in $Q_s$ which attained a maximum in a few hours and then gradually subsided.

(5) The lack of such response in depancreatized dogs similarly treated indicates that supply of serum amylase from extrapancreatic sources was not appreciably affected by these drugs.

(6) Following ligation of the pancreatic ducts a vigorous serum amylase response to the drugs could still be obtained for several days, but not after the lapse of several weeks, when extensive acinar atrophy had occurred.

(7) Paucity of response in $Q_s$ to injection of acetyl β-methylcholine with eserine appears to furnish an indication of subnormal pancreatic acinar functional ability.

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[27] An unqualified statement that a given specimen of dog serum contains ten times as much amylase as one of human serum is therefore meaningless.
[28] This unit is approximately 1.63 times that employed by Johnson and Wies.[3]

[29] A fiber so small as to be almost imperceptible may introduce a gross error in viscosimetry. We avoid, therefore, the use of cotton plugs in any apparatus associated with this technic. With care, salivary contamination of solutions may be avoided without the use of plugged pipettes.

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[33] We are indebted to Drs. C. G. Burn of the Dept. of Pathology and T. W. Workman (D.V.M.) of the Dept. of Bacteriology and Immunology, who reviewed the microscopic preparations in this case.

[34] As a basis of comparison in these experiments the increments in $Q_s$ for the first two hours after injection may be taken. The ratio, $R$, of this response to the second injection relative to that for the first was 0.52 for the four day interval, and 0.91 and 0.70 for the seven day intervals. Disregarding the differences in these intervals, *log R* may be submitted to the *t-test* described by R. A. Fisher (Statistical Methods for Research Workers, Oliver and Boyd, London). On this basis $P = 0.15$, a considerable margin of doubt as to significance.

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[38] Popper, H. L.: Deutsch. Z. f. Chir., **221**, 273, 1929.

# INGUINAL HERNIA

## A REPORT OF 1,600 OPERATIONS

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THIS is a review of 1,600 consecutive operations for inguinal hernia performed at the Henry Ford Hospital during the ten year period 1920–1929.

The investigation was undertaken in an endeavor to determine, as accurately as possible, the end-results of the various operative procedures and to arrive at a definite figure for the recurrent rate. The method adopted was to arrange the cases into two groups—traced, and untraced. An arbitrary period for division between traced and untraced had to be fixed. Some of the published statistics are based on a six month follow up on the assumption that most recurrences appear within six months of operation. A suspicion was entertained that this period was too short; accordingly, a two year follow up period was chosen. Thus all patients who were not followed for at least two years subsequent to operation were listed with the untraced group. When the recall was completed and the records reviewed it was found that there were 800 operations in the traced, and 800 in the untraced group. The recall was effective in only 50 per cent of cases owing to the majority of the patients being drawn from the industrial population.

Final review of the records showed that there were 614 patients upon whom 800 inguinal hernia operations had been performed in the traced group and 633 patients upon whom the same number of operations had been performed in the untraced group. Except for the purpose of estimating the recurrent rate and the length of time followed, both groups are considered for statistical purposes, because it was believed valuable facts might be deduced from consideration of both groups as a whole.

*Sex.*—Inguinal hernia in the female is relatively infrequent since only 27 or slightly more than 1 per cent of the 1,600 operations were performed upon women as compared with 1,573 or 98.9 per cent upon males (Table I). Increased occupational hazards as well as developmental differences probably account for the predominance of the condition in the male.

TABLE I

SEX

| | Number of Patients | Percentage |
|---|---|---|
| Male | 1,573 | 98.9 |
| Female | 27 | 1.1 |

*Age.*—The youngest patient was a three week old infant with a strangulated hernia and the oldest a man of 89 with the same condition. Over 80 per cent. of the series falls in the third, fourth and fifth decades, *i.e.*,

between the ages of 21 and 50, the period of greatest physical activity (Table II).

TABLE II

AGE

| Age Group | Decade | Number of Patients | Percentage |
|---|---|---|---|
| 1– 10 | 1 | 51 | 3.2 |
| 11– 20 | 2 | 65 | 4.1 |
| 21– 30 | 3 | 402 | 25.1 |
| 31– 40 | 4 | 493 | 30.7 |
| 41– 50 | 5 | 392 | 24.5 |
| 51– 60 | 6 | 129 | 8.1 |
| 61– 70 | 7 | 60 | 3.8 |
| 71– 80 | 8 | 6 | 0.4 |
| 81– 90 | 9 | 2 | 0.1 |
| 91–100 | 10 | 0 | 0.0 |

*Obesity.*—Of the 1,600 operations performed for inguinal hernia, 114 or 7.1 per cent were recorded as having been performed upon obese individuals. The presence of excess fat in the subcutaneous and extraperitoneal tissues makes the operation technically more difficult, lengthens the operating time and increases the risk of infection. That these factors have an adverse effect upon the recurrence rate is indicated by the observation that of the 66 recurrences seven or 10.5 per cent occurred in overweight patients. Further incriminating evidence is introduced by pointing out that in the 800 operations in the traced group 58 were done on fat persons with seven recurrences, a percentage of 12.1, while the recurrent rate for the whole group was 8.25 per cent.

*Occupation.*—Occupations which entailed heavy lifting were engaged in by 1,320 or 82.5 per cent of the whole series while only 280 or 17.5 per cent pursued a sedentary type of work. These figures draw attention to the importance of trauma in etiology of hernia. Further emphasis is laid on this point by noting that of the 66 recurrences recorded 59 or 90 per cent occurred in patients who gained their living by hard labor (Table III).

TABLE III

OCCUPATION

| | Number of Patients | Percentage | Recurred | Percentage |
|---|---|---|---|---|
| Hard labor | 1,320 | 82.5 | 59 | 90 |
| Sedentary | 280 | 17.5 | 7 | 10 |
| Totals | 1,600 | 100.0 | 66 | 100 |

*Trauma.*—A definite history of injury was obtained 994 times or 62.1 per cent of the total number. It is interesting to conjecture the exact rôle played by trauma. A detailed interrogation regarding the accident will usually elicit the information that the foot on the involved side slipped while engaged in lifting a heavy object or that the individual was suddenly called upon to support a heavy weight without having time to brace himself. On

the other hand, severe strain with the feet firmly braced does not appear to be a factor in initiating the train of events which results in the appearance of a rupture. When the foot slips the thigh is flexed with consequent release of the tension on the aponeurosis of the external oblique muscle. In this manner the buttressing effect of the aponeurosis is removed and the internal inguinal ring rendered more vulnerable by being partially unguarded. Increased intra-abdominal pressure exerted against an internal ring already weakened by the presence of a preformed sac, and now lacking its outer guard, creates an ideal situation for the entrance of abdominal contents into the sac and the clinical appearance of a hernia. This suggests the importance of utilizing the external oblique aponeurosis in hernial repair.

TABLE IV

DURATION OF HERNIA BEFORE OPERATION

| | No. of Patients | Percentage | No. of Recurrences | Percentage |
|---|---|---|---|---|
| 1 day–1 week | 74 | 4.6 | 1 | 1.5 |
| 1 week–1 month | 236 | 14.8 | 11 | 16.6 |
| 1 month–6 months | 468 | 29.3 | 15 | 23.0 |
| 6 months–1 year | 196 | 12.2 | 11 | 16.6 |
| 1 year–5 years | 335 | 20.9 | 14 | 21.3 |
| 5 plus years | 219 | 13.7 | 10 | 15.0 |
| Congenital | 72 | 4.5 | 4 | 6.0 |
| Totals | 1,600 | 100.0 | 66 | 100.0 |

It will be noticed from a study of the figures in Table IV that the trend is toward early operation. Almost one-half of the patients were operated upon within six months of the development of the hernia; over 60 per cent within a year of onset, and 30 per cent within a month of its appearance. Those waiting over five years represented only 13.7 per cent of the total group. The time interval between the occurrence of the hernia and operation had no appreciable bearing on the recurrence rate. It will be seen that the figures in the percentage columns in Table IV closely approximate each other.

*Truss.*—Before operation 374 or 23.4 per cent of the herniae were retained by a truss. It has been stated that the wearing of a truss tends to weaken the tissue of the inguinal region by its continuous pressure, thus making repair less satisfactory. The statistics from this compilation do not bear out this contention, because of the 66 recurrences only 12 or 18.2 per cent had worn trusses.

*Incarceration.*—The operation for strangulated hernia today is a relatively infrequent surgical emergency. In this review only 22 or 1.4 per cent of the 1,600 operations were performed for incarcerated herniae and of this number only one required intestinal resection. This is an index of surgical progress and stands in marked contrast to the early publications on this subject, when strangulation was practically the only indication for operation.

The total number of herniae occurring on the right side exceeded that on the left in the ratio of 6 to 5. The difference between the right and left

side is even greater when the cases involving both sides are excluded and single herniae alone are considered. Here it is found that the ratio is 4 to 3. Recurrence, however, was found to be much more common on the left side since of the 66 recurrences 38 or 57.6 per cent followed left hernioplasties and 28 or 42.4 per cent followed right hernioplasties, thus reversing the 4 to 3 ratio. The same observation may be brought out in another way by consideration of the fact that there were in the traced group 420 right sided herniae with 38 recurrences, a rate of 6.7 per cent, and 380 left sided herniae with 38 recurrences, a rate of 10 per cent. Bilateral herniae were found in 353 or 28.3 per cent of the 1,247 patients in the series (Table V).

TABLE V

SIDE INVOLVED

| | No. of Herniae | Percentage | No. of Recurrences | Percentage Each Side |
|---|---|---|---|---|
| Right | 872 | 54.5 | 28 | 42.4 |
| Left | 728 | 45.5 | 38 | 57.6 |
| Totals | 1,600 | 100.0 | 66 | 100.0 |

| | No. of Patients | Percentage |
|---|---|---|
| Right side alone | 519 | 41.6 |
| Left side alone | 375 | 30.1 |
| Bilateral | 353 | 28.3 |
| Totals | 1,247 | 100.0 |

| | Operations Traced | Recurrence | Percentage |
|---|---|---|---|
| Right | 420 | 28 | 6.7 |
| Left | 380 | 38 | 10.0 |

*Anesthetic.*—An examination of the anesthetic charts of these patients reveals the great change in anesthetic methods that took place during the decade 1920–1929. At the beginning of this period open ether was used in nearly all cases. Then, with the advent of gas anesthesia, nitrous oxide and ether were employed for a short time. This was soon supplanted by ethylene, which was used in over 60 per cent of the cases, either alone or in combination with ether. Spinal anesthesia was just coming into vogue at the close of this period as is indicated by its use in only 8 per cent of the operations. These figures are now reversed, for over 90 per cent of the present day herniotomies at this hospital are done under spinal anesthesia. The perfect relaxation resulting from this anesthetic procedure makes it easy to obtain a high ligation of the sac, since the omentum and intestines are at rest and not continuously pushing up into the wound as is the tendency when inhalation anesthesia is employed. Furthermore, the identification and repair of the transversalis fascia is rendered less difficult because of the ease with which retraction of the transverse muscles is obtained. Spinal anesthesia is definitely contra-indicated in the poor risk patient and in our experience it has not reduced the incidence of postoperative respiratory complications.

Local anesthesia was infrequently used, only 36 or 2.3 per cent of the total operations having been done with novocain. It was employed with advantage in patients in whom a general or spinal anesthetic was contra-indicated because of hypertension, respiratory infection or poor general condition associated with neglected strangulation.

TABLE VI

ANESTHETIC

| | No. of Operations | Percentage |
|---|---|---|
| Ethylene and ether | 524 | 32.8 |
| Ether | 475 | 29.7 |
| Ethylene | 359 | 22.4 |
| Spinal | 129 | 8.0 |
| Nitrous oxide—ether | 77 | 4.8 |
| Local | 36 | 2.3 |

*Classification.*—Only 15.7 per cent of the herniae were direct. Indirect inguinal herniae predominated over the direct variety in a ratio of greater than 5 to 1. In the traced group of cases there were 154 direct herniae of which 18 or 11.6 per cent recurred, while out of the 646 indirect herniae in the same group 48 or 7.4 per cent recurred. Thus the probability of recurrence after operation is more than 50 per cent greater in a direct than in an indirect hernia. The saddle-bag or pantaloon type of hernia was found in 126 or 7.9 per cent of the total operations. This special classification was included with the direct herniae, since protrusion of the medial part of the sac through Hesselbach's triangle demands plastic repair of the area. Failure to recognize the presence of a double sac is one of the principal causes of recurrence after operation. In this review seven or 10.6 per cent of the 66 recurrences followed repair of saddle-bag herniae. This is practically the same figure as obtained in simple direct hernia.

Sliding hernia, where a portion of the sac was formed by the peritoneum covering the sigmoid colon, was noted in 53 or 3.3 per cent of the total operations. In spite of the fact that a high closure of the sac could not be made, the recurrence rate was not adversely affected since only one or 1.5 per cent of the total recurrences followed repair of a sliding hernia (Table VII). It was not found necessary to resort to intra-abdominal fixation of the pelvic colon or to the Moschowitz operation in any of these cases.

*Size of Hernial Sac.*—A moderate sized hernial sac, that is one which occupies the inguinal canal throughout its extent but does not enter the scrotum, was described in 1,040 or 65 per cent of the total operations. Large complete scrotal sacs and small sacs were found in about equal numbers, comprising the remaining 35 per cent in the proportion of 17.3 and 17.7 per cent, respectively. The size of the hernial sac had little if any bearing on the percentage of recurrence, inasmuch as there is not a great variation of figures in the percentage columns in Table VIII. This shows that the proportionate rate of the various sized herniae for the whole group and for the recurrences is practically the same. These figures fail to substantiate the

TABLE VII

CLASSIFICATION OF HERNIAE

| | Total No. of Herniae | Percentage |
|---|---|---|
| Indirect | 1,349 | 84.3 |
| Direct | 251 | 15.7 |
| Totals | 1,600 | 100.0 |

| | No. of Cases | Percentage | Recurred | Percentage |
|---|---|---|---|---|
| Saddle-bag | 126 | 7.9 | 7 | 10.6 |
| Sliding | 53 | 3.3 | 1 | 1.5 |

| | Traced Herniae | Recurrent | Percentage |
|---|---|---|---|
| Indirect | 646 | 48 | 7.4 |
| Direct | 154 | 18 | 11.6 |
| Totals | 800 | 66 | 8.25 |

claim that large herniae are more difficult to cure. The implied indictment of small herniae may be explained on the ground that the surgeon may be less careful with the repair when the sac is small.

TABLE VIII

SIZE OF THE HERNIAL SAC

| Size | No. of Patients | Percentage | Recurred | Percentage |
|---|---|---|---|---|
| Moderate | 1,040 | 65.0 | 41 | 62.1 |
| Small | 284 | 17.7 | 14 | 21.2 |
| Large | 276 | 17.3 | 11 | 16.7 |
| Totals | 1,600 | 100.0 | 66 | 100.0 |

*Method of Closing the Sac.*—The most popular method of closing the hernial sac was by twisting the neck and then doubly transfixing it with heavy silk sutures. This was done in 762 or 46.4 per cent of the total operations with eminently satisfactory results. It gives the highest possible closure of the sac and when completed it presents, on the abdominal surface, a firm buttress of tissue instead of the dimple shown after alternative methods of closure. Unfortunately, it can be utilized only when the neck of the sac is small or of moderate size. Next in choice was the straight continuous suture, similar to the suturing of the peritoneum after a laparotomy. It was made use of in 335 cases or 21 per cent of the total. Its special adaptation is in the closure of large direct sacs where the proximity of the bladder renders twisting of the neck of the sac inadvisable and when a satisfactory closure cannot be accomplished with the purse string suture because of excess preperitoneal fat. The purse string suture, a valuable method of closing the neck of the sac, was used in 253 or 16 per cent of the cases. Next to twisting, it accomplishes the highest closure and when reinforced by a second similar suture, an admirable protective pad is formed at the internal ring. It can even be used in large hernial sacs encroaching on the bladder if the

preperitoneal fat is not too abundant. Transfixion of the neck of the sac is useful only in recent herniae with long narrow necked sacs. It was employed in 197 or 12.3 per cent of the series. The sac was not opened in 53 cases or 3.3 per cent of the operations. Failure to open the peritoneal cavity during the course of a hernial operation should be considered as a technical error on the part of the surgeon. A potential indirect sac can always be found at the internal ring if a careful search is made. This sac should invariably be opened and the inguinal region explored from within. In this manner it is frequently possible to demonstrate the presence of a small direct or even a femoral hernia, previously overlooked. In the cases under review there were 24 in the traced group where the sacs were not opened, and of these two recurred. The obvious inference is that the sacs were overlooked by the surgeons at the time of operation, a mistake that would not have been made had the peritoneal cavity been entered at the internal ring.

Reference to Table IX shows the relative value of the different methods of closing the sac with reference to the recurrent rate. This suggests that transfixion and purse string sutures give the best and straight sutures the poorest results. In considering the merits it should be remembered that transfixion is used only in small herniae and that straight suture is made use of in large direct hernial sacs. Thus a direct comparison is not justifiable since the recurrence rate might be expected to be high in cases closed with straight suture and low in sacs closed by transfixion. Furthermore, the good showing of the twisting method must be due in part at least to the fact that only small and moderate sized hernial sacs are suitable for that technic. The record of the purse string suture is excellent taking into consideration its wide adaptability.

TABLE IX

METHOD OF CLOSING THE SAC

| Method | No. of Herniae | Percentage | Recurred | Percentage |
|---|---|---|---|---|
| Twisting | 762 | 47.4 | 27 | 40.9 |
| Straight suture | 335 | 21.0 | 20 | 30.3 |
| Purse string | 253 | 16.0 | 11 | 16.7 |
| Transfixing | 197 | 12.3 | 6 | 9.1 |
| Not opened | 53 | 3.3 | 2 | 3.0 |
| Totals | 1,600 | 100.0 | 66 | 100.0 |

*Choice of Operation.*—The Halsted operation was performed 1,386 times or 86.6 per cent of the total operations, and the Bassini operation was performed on 214 occasions or 13.4 per cent of the total. The Halsted technic as followed in this hospital is that described by Halsted in his later publications on hernia. Essentially it is the same as the Ferguson operation, for in both, the structures forming the spermatic cord are buried beneath the internal oblique and transversalis muscles. The Halsted operation in addition calls for a high ligation of the sac, utilizes the cremaster muscle and fascia

in the repair and emphasizes imbrication of the aponeurosis of the external oblique muscle. It provides better support for the internal ring than any other type of operation yet devised. For this reason it is ideal for the repair of indirect herniae where the defect is confined to the internal ring. The necessity for providing a path of exit for the cord at the pubic spine renders this technic unsuitable in the treatment of direct herniae because it fails to supply additional support to Hesselbach's triangle at its most vulnerable spot. This region at the medial attachment of Poupart's ligament, and in close proximity to the pubic spine, is the common site of recurrent direct herniae. Adequate repair of this area can be carried out only when the cord is transplanted above the internal oblique and transversalis muscles, as in the original Bassini operation. The reinforcement may be augmented by imbricating the external oblique aponeurosis under the cord as originally done by Halsted and as recently advocated by Stetten. This modification was employed in only 11 or 5 per cent of the 214 Bassini operations.

The Bassini technic also has its weak point and this, too, is associated with the emergence of the cord. Here, the region of the internal ring is inadequately protected, a deficiency that may be obviated, to some extent, by placing a suture external to the internal ring, due care being taken not to include the ilio-inguinal nerve when inserting the needle. The problem of hernial repair is thus a question of what to do with the cord. If technical errors are eliminated, recurrences after the use of the Bassini technic are found at the internal ring, because of the impossibility of complete closure of this area. On the other hand, when the Halsted operation is correctly employed recurrences are found coming directly through the most medial part of Hesselbach's triangle because of the inadequate support of this region. The question of which operation to use should be decided at the operation table.

After the sac is opened the integrity of the floor of Hesselbach's triangle should be tested by the forefinger of the surgeon applying pressure to the internal surface of this structure. If there is the slightest evidence of weakness the Halsted type of operation is obviously unsuitable. Complete rupture of the transversalis fascia is found in direct herniae, and bulging, to a varying degree, is noted in obese individuals and those past middle life. This group of cases demands the Bassini operation. Closure of the rent in the transversalis fascia or plication of the structure, when it is stretched, is an essential step in the operation. A vertical incision through the anterior rectus sheath just lateral to the attachment of the external oblique aponeurosis will facilitate the closure of Hesselbach's triangle by allowing approximation of the tissues without tension on the sutures. This procedure was applied in 41 or 19.2 per cent of the 214 Bassini operations. The Halsted technic gives satisfactory results in indirect hernia in the young, and when there is no impairment of the musculature or fascia. It has the great advantage of being simple and easier to perform and of minimizing trauma to the cord and other structures. In this analysis the recurrence rate is found

to be approximately the same for both operations. In the traced group there were 127 Bassini operations, with 11 or 8.6 per cent recurrences, and 673 Halsted operations with 55 or 8.3 per cent recurrences. Undoubtedly the recurrence rate for the whole group would have been materially reduced had the cord been transplanted in some of the cases that recurred after the employment of the Halsted operation.

TABLE X

CHOICE OF OPERATION

| Type | No. of Patients | Percentage | Operations Traced | Recurred | Percentage |
|---|---|---|---|---|---|
| Halsted..... | 1,386 | 88.6 | 673 | 55 | 8.3 |
| Bassini..... | 214 | 13.4 | 127 | 11 | 8.6 |

*Suture Material.*—Following the teaching of Halsted, silk was used as the suture material in 1,545 or 96.6 per cent of the operations. In the remaining 3.4 per cent chromic catgut was employed. Silk has many advantages over catgut. The same tensile strength can be obtained with a finer suture, thus reducing the amount of tissue trauma. The suturing can be done with a finer needle thus diminishing the tendency to separation and tearing of the fibers of Poupart's ligament. Furthermore, there is less injury to the nutrient blood vessels of the soft tissues with a corresponding reduction in tissue loss. Unabsorbable sutures keep the tissues in apposition until fibrous tissue repair has organized, thereby diminishing the possibility of separation of important structures when subjected to undue strain during the immediate postoperative period. There is less tissue reaction with silk than with catgut, a fact that may be verified by repairing one side of a bilateral hernia with silk and the other side with catgut. The only valid argument against the use of silk in the repair of herniae is the problem of infection. A certain number of hernial wounds will become infected in spite of every precaution being taken against the introduction of pyogenic organisms. When infection occurs in a wound in which the repair has been made with silk, a real complication presents itself. Healing is delayed for a prolonged period due to the foreign body reaction of the silk. Draining sinuses persist until all the silk sutures in the involved area are discharged. This complication, though not disabling, is annoying to the patient and serves as a constant reminder to the surgeon of his faulty asepsis. The use of silk, therefore, should be restricted to operations performed under ideal conditions. Fascial sutures were not employed in any of the operations in this series.

*Bilateral Operations.*—Table XII shows that 28.3 per cent of the patients had bilateral operations. This brings up the question of the advisability of doing both sides at one sitting. From an economic viewpoint it is an apparently ideal arrangement for the patient. The idea of one hospitalization, one absence from work and one surgeon's fee has much to commend it but,

as will be shown, both recurrences and complications are much increased in those individuals subjected to bilateral hernia operations. In this series 43 or 65 per cent of the 66 recurrences followed bilateral operations. Thus, while only one-quarter of the patients have both sides repaired, two-thirds of the recurrences were found in this group. The case against bilateral operation is strengthened by noting that out of the total 1,600 operations 83 or 5 per cent were complicated during the postoperative period by sundry conditions and that out of 353 bilateral operations 27 or 7.8 per cent failed

TABLE XI

SUTURE MATERIAL

| | No. of Patients | Percentage |
|---|---|---|
| Silk | 1,545 | 96.6 |
| Catgut | 55 | 3.4 |
| Fascial sutures | 0 | 0.0 |
| Totals | 1,600 | 100.0 |

to enjoy an uneventful convalescence. This shows an increase of over 50 per cent. The underlying factors contributing to these occurrences are apparent. First, there is the observation that owing to an element of fatigue some surgeons may be a little less thorough when repairing the second side, a situation which is certain to increase the number of recurrences. Moreover, the prolonged anesthetic necessary for a double operation predisposes to an increase in pulmonary complications, and finally, wound infections increase in direct proportion to the length of time consumed in performing the operation.

TABLE XII

BILATERAL OPERATIONS

| | No. of Patients | Percentage | Recurrences | Percentage |
|---|---|---|---|---|
| Single operations | 894 | 71.7 | 23 | 35 |
| Bilateral operations | 353 | 28.3 | 43 | 65 |
| Total patients | 1,247 | 100.0 | 66 | 100 |
| Total operations | 1,600 | | | |

In addition to repair of the hernia, other operations were performed on 166 occasions or in 10.4 per cent of the series. Of these additional operations 105 or 63.3 per cent were for the correction of conditions existing in the genitalia. The appendix was removed in 32 cases or 19.3 per cent of this special group but in only 2 per cent of the total operations (Table XIII). The performance of additional operations had no effect on the recurrence rate. In the traced group of cases there were 82 associated operations with only four recurrences, a percentage of 4.9. This compares favorably with a total recurrence rate of 8.25 per cent.

Additional surgery definitely increased the complications of hernia operations. Wound infection occurred once, or in 3.1 per cent of the 32 patients

who underwent appendectomy at the same time as the herniotomy, while the percentage of infection for all the operations was only 1 per cent. Hydrocele operations appear to occasion the greatest number of complications. It is shown that of the 42 hydrocele operations 9 or 21.4 per cent were complicated by hematomata or testicular swelling and that testicular atrophy resulted in two instances.

TABLE XIII

ASSOCIATED OPERATIONS

| | No. of Operations | Percentage |
|---|---|---|
| (1) On the genitalia | 105 | 63.3 |
| Hydrocele | 42 | |
| Orchidopexy | 23 | |
| Varicocele | 21 | |
| Circumcision | 14 | |
| Orchidectomy | 3 | |
| Spermatocele | 2 | |
| Total | 105 | |
| (2) Appendectomies | 32 | 19.3 |
| Through hernial incision | 24 | |
| Through separate incision | 5 | |
| With hysterectomy | 1 | |
| With salpingo-oophorectomy | 1 | |
| With cholecystectomy | 1 | |
| Total | 32 | |
| (3) Miscellaneous | 16 | |
| Resection varicose veins | 4 | |
| Hemorrhoidectomy | 2 | |
| Salpingo-oophorectomy | 2 | |
| Intestinal resection | 2 | |
| Thyroidectomy | 1 | |
| T and A | 1 | |
| Adenoidectomy | 1 | |
| Lipectomy | 1 | |
| Hysterectomy | 1 | |
| Vas section | 1 | |
| Total | 16 | |
| (4) Other herniae | 13 | |
| Femoral | 7 | |
| Umbilical | 3 | |
| Postoperative ventral | 2 | |
| Epigastric | 1 | |
| Total | 13 | |
| Total associated operations | 166 | |

*Postoperative Complications.*—As is shown in Table XIV, 83 or 5 per cent of the total operations were complicated by a variety of conditions. The

largest group is made up of pulmonary affections which occurred in 33 or 2.7 per cent of the patients. This complication was also the most serious, being responsible for the three deaths which occurred, a mortality rate of 0.24 per cent. One fatality resulted from bronchopneumonia and two from pulmonary embolism. The coughing and sneezing incidental to upper respiratory infection did not appear to have any special bearing on the recurrence rate since of the 66 recurrences only 3 or 4.6 per cent appeared in patients whose postoperative convalescence was complicated by respiratory infections. Wound infection occurred in 16 cases or 1 per cent of the total number. It is usual to place wound infection in the list of causative factors of recurrence of inguinal hernia after operation, however, in this review the case against infection is not pronounced since in only 2 or 3 per cent of the 66 recurrences had wound infection been present.

Hydrocele was noted as occurring after operation 14 times or almost 1 per cent of the total cases. In some instances it followed variocele operations, in others it was occasioned by trauma to the cord during the course of the operation or by leaving insufficient room for it to emerge. Swelling of the testicle after operation for hernia is evidence of interference with its blood supply. Its importance is due to the fact that swelling may be followed by atrophy of the testicle, a sequela which was observed on 4 or 0.5 per cent of the 800 traced operations. Hematomata in the wound after hernia operation is not of great significance. Complete absorption takes place under conservative treatment. Attempts at evacuation are almost certain to lead to wound infection.

Phlebitis is fortunately a rare complication of herniotomy. It appeared three times or in 0.18 per cent of the total operations. It is an extremely disabling condition because the deep venous circulation is destroyed. When the complication makes its appearance the victim is actually fortunate. Clinical phlebitis means that the patient has escaped the danger of pulmonary embolism, since the clot in the iliac veins has become organized rather than dislodged.

The patient whose operation is complicated runs a little more risk of recurrence than one whose convalescence is uneventful. The difference is not as great as might be expected since of the 800 traced operations 50 or 6.25 per cent had complications and of the 66 recurrences in this group five or 7.6 per cent had complications.

*Follow-Up.*—Table XV demonstrates the ineffectiveness of the follow-up system. The difficulty in tracing patients is in direct ratio to the time which has elapsed since operation. A fair degree of success was obtained until the fifth year had passed, since over 70 per cent of the traced cases were recalled during this period, and only 30 per cent after this time. The right hand column must be divided by two, in order to arrive at the follow up percentage for each year inasmuch as only one-half of the total operations were traced.

TABLE XIV

COMPLICATIONS FOLLOWING OPERATION

| | | | | |
|---|---|---|---|---|
| (1) | Pulmonary complications | | | Percentage |
| | Bronchopneumonia | 14 | | |
| | Bronchitis | 7 | | |
| | Atelectasis | 6 | | |
| | Pulmonary embolism | 3 | | |
| | Lobar pneumonia | 1 | | |
| | Pulmonary infarct | 1 | | |
| | Lung abscess | 1 | | |
| | | 33 | 33 | 2.7 |
| (2) | Wound infection | | 16 | 1.0 |
| (3) | Hydrocele | | 14 | |
| (4) | Hematomata | | 13 | |
| (5) | Testicular atrophy | | 4 | |
| (6) | Phlebitis | | 3 | |
| | Total | | 83 | 5.0 |
| | Mortality | | 3 | 0.24 |

TABLE XV

FOLLOW-UP

| Time Elapsed since Operation | No. of Patients | Percentage |
|---|---|---|
| 2 years | 186 | 23.2 |
| 3 " | 140 | 17.5 |
| 4 " | 138 | 17.2 |
| 5 " | 109 | 13.6 |
| 6 " | 67 | 8.3 |
| 7 " | 56 | 7.0 |
| 8 " | 24 | 3.0 |
| 9 " | 4 | 0.5 |
| 10 " | 10 | 1.2 |
| Recurrences | 66 | 8.5 |
| | 800 | 100.0 |

*Time of Recurrence.*—Table XVI indicates that one-half of the recurrences were observed within one year of operation and that one-third were noted more than two years after operation. The exact time the hernia recurred is often difficult to evaluate. Only where there is an associated trauma can the time be fixed with any degree of certainty. During the first year following operation, when the experience is fresh in the individual's mind, he is likely to be conscious of changes occurring at the operative site, and to seek the advice of the surgeon. As time goes on, however, a recurrence of the hernia may take place without the knowledge of the patient concerned. In these cases the failure of repair is often discovered only when a physical examination is demanded for insurance purposes or for reemployment. It is this fact that lulls the patient into a false sense of security and

causes the surgeon to give a low estimate of his recurrences. The figures in this table denote the futility of attempting to draw inferences regarding the recurrence rate from a short period of observation.

TABLE XVI

TIME OF RECURRENCE

| Time | No. of Patients | Percentage |
|---|---|---|
| 1–12 months | 33 | 50.0 |
| 1– 2 years | 11 | 16.7 |
| 2–10 years | 22 | 33.3 |

*Recurrences.*—There were 66 recurrences out of the 800 cases followed. This gives a recurrent rate of 8.25 per cent for the group. Direct herniae had 50 per cent more recurrences than indirect. The recurrence percentage was practically the same for both the Halsted and the Bassini method of repair. These figures are based on an examination by a competent observer of the operative site in all cases. The minimum time between operation and examination was two years and the maximum ten years. The recurrence rate is not so low as some published statistics but it is based on facts, not estimates. The literature on this subject quotes various figures for the recurrence rate ranging from 1 to 25 per cent. The observation is noteworthy—that the more complete the follow up and the larger the period covered, the greater the number of published recurrences. There can be no doubt that the number of recurrences is greater than the published results would indicate. It is obvious that a definite figure for the recurrence rate is difficult if not actually impossible to determine with any degree of accuracy. The follow up system to be 100 per cent perfect should continue throughout the individual's life. Furthermore, the recurrence rate is modified to some extent by the individual's occupation.

TABLE XVII

RECURRENCES

| | Operations Traced | Recurred | Percentage |
|---|---|---|---|
| Total | 800 | 66 | 8.25 |
| Indirect | 646 | 48 | 7.4 |
| Direct | 154 | 18 | 11.6 |
| Halsted repair | 673 | 55 | 8.3 |
| Bassini repair | 127 | 11 | 8.6 |

*Individual Surgeon's Recurrence Record.*—The vast majority of these operations were performed by the staff and resident surgeons; only 165 cases, or just over 10 per cent, were done by the assistant resident surgeons and these always under supervision. They are listed with a miscellaneous group designated by the letter "L." It will be seen by reference to Table XVIII that the number of recurrences for this group is less than the average for all the operations. The explanation of this lies in the fact that only straightforward cases were alloted to these surgeons. A study of Table XVIII indicates that while there is a definite variation in the record of indi-

vidual surgeons, the time factor must be taken into account. The contention that the rate of recurrence increases in direct proportion to the time elapsed since operation is very well brought out in this table. Here it is shown the best results were obtained by those surgeons against whom the time factor had not yet been brought into play. When a hernia recurs after operation it can usually be charged as a technical error on the part of the operator. The veracity of this statement is based first on the observation that the recurrence rate among individual surgeons varies considerably and second to the fact that the majority of the recurrences in this compilation which returned for a second operation remain cured. It follows therefore that a technic which cures a recurrent hernia, when operation is admittedly more difficult, would have been equally effective at the first operation. This would indicate that improvement in the results of hernial repair will come not from inventing new operations, but from carefully following certain well defined principles which now yield excellent results when properly applied.

TABLE XVIII

INDIVIDUAL SURGEON'S RECURRENCE RECORD

| Arranged in Order of Seniority | As to Number of Traced Operations Performed | | As to Percentage of Recurrences | |
|---|---|---|---|---|
| A | I | 124 | K | 0.0 |
| B | F | 121 | J | 3.3 |
| C | D | 82 | F | 4.3 |
| D | C | 74 | A | 4.4 |
| E | E | 73 | I | 5.6 |
| F | B | 70 | L | 5.7 |
| G | A | 68 | B | 8.5 |
| H | L | 67 | H | 8.6 |
| I | H | 35 | G | 9.5 |
| J | K | 35 | D | 10.0 |
| K | J | 30 | C | 14.8 |
| L | G | 21 | E | 14.9 |

## SUMMARY AND CONCLUSIONS

(1) A follow up period of two years or more was obtained in 800 cases, which showed a recurrence rate of 8.25 per cent.

(2) The recurrence rate for indirect hernia was 7.4 per cent, and for direct hernia 11.6 per cent.

(3) The longer the time which had elapsed since operation, the greater was the number of recurrences.

(4) In indirect herniae, the essential step in the operation is high removal of the sac.

(5) In direct herniae, special attention must be given to repairing and reinforcing the floor of Hesselbach's triangle.

(6) The importance of the repair of the transversalis fascia in the cure of direct herniae is emphasized.

(7) Small herniae in young adults can be cured without transplantation

of the cord but in all direct herniae. In indirect herniae occurring in fat individuals, in those past middle life, and where the sac is large, transplantation of the cord is essential to success.

(8) Bilateral operations show an increase in both complications after operation and in the recurrence rate.

(9) The recurrence of a hernia after an operation is usually the result of a technical error on the part of the surgeon.

The author wishes to acknowledge, with gratitude, the inspiration, advice and helpful criticism of the Surgeon-in-Chief, Dr. Roy D. McClure.

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# TETANUS*

## EXPERIENCE IN THE EPISCOPAL HOSPITAL IN THE PAST 30 YEARS (1905–1935)

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THERE are no reliable statistics concerning the incidence of tetanus in the United States, but we do know that there were 1,253 deaths from the disease in this country in 1933. This corresponds to a death rate of about one per 100,000. Contrast this with two per 1,000 wounded in the Civil War, and two per 10,000 wounded in the World War. These figures show why studies based on cases in civil practice are so limited, although hospitals in some sections of America have had a suprisingly large experience.[1]

In the past 30 years there were 56 cases of tetanus admitted to the Episcopal Hospital. Most of these occurred during the warm months, with the peak in July, although none followed injuries from fireworks, and most of them came to us in clusters of two or three. It is, perhaps, well to emphasize the fallacy of attempting to deal too seriously with such a small series by the statistical method. The patients ranged in age from four years to 63, most being between seven and 15. Fifteen (26 per cent) were females, and 41 (74 per cent) males. Of the 56 patients treated, 16 were cured and 40 died (72 per cent). Males showed a 73 per cent mortality (30 out of 41); females 67 per cent (10 of 15).

Table I summarizes the results of the various means of emergency care:

TABLE I

EFFECT OF EMERGENCY TREATMENT (Prophylaxis)

| | Cured | Died | Mortality |
|---|---|---|---|
| Number receiving prophylactic serum | 1 | 4 | 80 per cent |
| Number receiving emergency care | 5 | 11 | 69 per cent |
| Total number of cases regardless of care | 16 | 40 | 72 per cent |

Is one to gather from this that the prophylactic use of tetanus antitoxin is worthless? At first sight this would seem to be the only conclusion to be drawn from the figures showing a higher mortality following the use of prophylactic serum than uninjected cases. However, the larger experience of Army surgeons so absolutely contradicts our own that it almost goes without saying that prophylactic antitoxin is decidedly effective. For example Ashhurst[2] cites Sanford, who attributed the drop in incidence from two per 1,000 in the Civil War to less than two per 10,000 in the World War to the use of prophylactic serum. He says, "Even allowing for the vast improvement in the mechanical and chemical disinfection of wounds, such a remarkable diminution could never have been secured without the

* Read before the Philadelphia Academy of Surgery, November 4, 1935.

use of antitoxin, especially in view of the highly contaminated nature of the fighting terrain." Ashhurst[2] cites other foreign authorities summarized below, reaching the conclusion that prophylactic injection of tetanus serum is without doubt, beneficial.

| Author | No. Wounded | Serum | Tetanus | No Serum | Tetanus |
|---|---|---|---|---|---|
| Bazy | 200 | 100 | 1 (day after) | 100 | 18 |
| Columbina | 200 | 198 | 0 | 2 | 2 |
| Walther | 270 | ? | 1 (day after) | ? | 18 |
| Fredet | 12 (German) | 0 | 0 | 12 | 6 |
| Fredet | ? (French) | all | 0 | 0 | 0 |
| Bruce | 1,000 | 0 | 0 | 1,000 | 15–32 |
| Bruce | 1,000 | 1,000 | 2–3 | | |

Bruce,—British army cut off at Kut-el-Amara. Tetanus incidence rose. Aviator dropped serum—incidence fell.

There only remains for discussion how much, where, and when to administer the antitoxin for prophylaxis. A unit of tetanus antitoxin is ten times the least amount necessary to save the life of a 350 Gm. guinea-pig for 96 hours against the official test dose of standard toxin. The test dose is 100 M.L.D. Therefore, in a man weighing 70 Kg. (154 lb.), a comparable dose would be 20 units. However, since man is one of the most susceptible of all animals (horses and Negroes are the most susceptible, chickens the least), and since toxin production in the body increases out of all proportion to the time elapsing since the inoculation, larger doses are used. Fifteen hundred units would seem to be ample. As the toxin travels via the paths of motor nerves (Meyer and Ransom[3]), it is rational to inject the antitoxin deeply into the injured member, if this is practicable. The time element cannot be overemphasized, also the practice of the emergency surgeon should be condemned in postponing the injection till a more convenient time. Multiple injections after an interval are frequently indicated, as the antitoxin is known to be eliminated in about 12 days. This is especially important in those cases which remain infected or in which secondary interference is necessary, as under those circumstances tetanus spores may suddenly develop into virulent toxin producing organisms. Tetanus following two or more injections is extremely rare.

One, however, should not place too much confidence in prophylactic serum; we have had an unfortunate experience with it, as has the Cook County Hospital.[4] It is important to realize that one must not develop a false sense of security which might lead to neglect of surgical prophylaxis—for proper care of the primary wound is by far the most important single step in the prophylaxis of this disease. The organism inhabits the intestinal tract of cattle and humans, and is present almost universally in soil, especially cultivated ground. The hospitals in Lancaster, Pa., an agricultural area, report 96 cases during the same 30 year period that the Episcopal Hospital had but 56.[5]

In fact, the rarity of the disease belies the universal distribution of its germ, a fact which has led some observers to search for antibodies in the

serum of normal persons. Factors involving anaerobiosis, such as mechanical exclusion of air, presence of symbiotic aerobes, dead tissue, foreign bodies, *etc.*, must be removed. (Modern prophylactic packages of antitetanic serum contain sera against various kinds of gas bacilli). Strong chemicals or caustics should not be applied because they reduce the vitality of the tissue, nor are oxidizing agents of the slightest value, probably because of the great reducing power of the tissues. Tincture of iodine painted in the vicinity of the wound is probably beneficial because of the induced hyperemia, not because it is a chemical antiseptic. Wounds of the lower extremity, puncture wounds, splinters, burns, compound fracture, and gunshot or blank cartridge wounds require special care; and vaccinations, in former years, showed a rather high incidence of tetanus. Coal mine injuries, on the other hand, are said to be very unlikely to be followed by tetanus, although Becker[6] reports its occurrence in miners after injury with coal. It may be noted in our own series, a fact which is stressed by Taylor,[7] namely, that in acute tetanus apparently innocent or clean wounds are rarely really clean, but that foreign bodies and necrotic tissue are often found when such wounds are opened. Perhaps that is why trivial injuries, such as punctures, abrasions, vaccinations, *etc.*, have a worse record than serious ones, as compound fractures and traumatic amputations in our series. In other words, severe wounds receive more radical primary care, far and away the most important single item in the prevention of tetanus.

In concluding this discussion of tetanus prophylaxis, it should be noted that the shortcomings of the injection of antitoxin have stimulated a search for a biologic method devoid of the inconveniences and dangers of serum, with the result that active immunization of humans with tetanus toxoid bids fair to develop into a practical method of immunization. Sneath,[8] and Bergey[9] point out that tetanus toxoid, made by treating the toxin with formalin, may be used to raise the titer of antibodies in human serum to significant amounts when injected in suitable quantities at proper intervals. However, these antibodies disappear in about a year, but may be called forth again very rapidly whenever necessary by a single subsequent injection of toxoid. Bergey suggests that persons exposed to a tetanus hazard be prepared in advance by three inoculations of tetanus toxoid. Then, in the event of a probable later need for rapid prophylaxis, a single dose of the toxoid will be enough to induce immunity. A similar method, using the inhalation route instead of the hypodermic, has been tried, but has not yet emerged from the experimental stage.[10]

*Treatment.*—The treatment of tetanus resolves itself into four phases: (1) Care of the focus. (2) Treatment of the intoxication. (3) Symptomatic treatment. (4) Maintenance of nutrition and fluid balance.

Care of the focus is placed first because to speak of the specific treatment without mentioning surgical treatment would be taking the risk of creating a false impression. Taylor lays great stress upon removal of original focus. He treats a case of acute tetanus as an emergency operation. In our own experience we have had nothing like the brilliant results which Taylor

claims for this method. For example, in four infected wounds excised in our own series, two were fatal. Two amputations also resulted fatally. It would seem more rational to treat the symptoms and the toxemia first, but by no means to neglect radical surgical care (preferably excision) of the focus.

Treatment of the intoxication is quite unsatisfactory. Tetanus toxin travels via motor nerves, probably along the axis cylinders, though also possibly through the perineural lymphatics, to the central nervous system (Meyer and Ransom[3]). Wassermann and his associates have shown that central nervous tissue has the greatest affinity for the poison, and that motor nerves possess this same power of neutralizing the toxin, but to a less degree, as the distance from the central nervous system increases. The poison circulates in the blood, and possibly in the lymph, but it is extracted from there by motor end-plates throughout the body, thus explaining why trismus is often the first sign (short pathway from blood via motor nerves to brain), even when the focus is at some distant point, as in the foot. Toxin ununited to nerve tissue is the only portion which antitoxin can affect. Unfortunately, it is only bound, unreachable toxin, which causes symptoms.

Other factors influencing the outcome of serum treatment are (1) the incubation period (long incubations are less dangerous than short ones), (2) severity of the disease, (3) the promptness with which treatment is instituted. (In our series, incubation periods of seven days or less (minimum four days) gave an 80 per cent mortality; those of 14 days or longer, maximum 32 days, a 67 per cent mortality.) Our series shows no decline in mortality rate as the years go by, in spite of ever increasing amounts of antitoxin, nor does one method of injection seem to be of more benefit than another. Nevertheless, until there is positive evidence to the contrary, it is my opinion that antitoxin should be used in treatment because it is rational.

There would seem to be no good reason for piling up tremendous doses of this expensive remedy, in spite of the good showing which large doses seem to make in mortality tables. Such figures, one must remember, are usually large because the patient lived long enough to get an accumulation of doses which looms large in the aggregate.

Injection into the nerves was practiced several times in our series, but it would seem like a hopeless task to blockade the huge area involved in small branches, while toxin floats everywhere in the serum to be absorbed by motor end-plates all over the body. Likewise, subcutaneous or intramuscular injections are objectionable because of the huge doses necessary. Fifteen to 25,000 units intravenously are probably equivalent to 100,000 units hypodermically. Intraspinal injection is irrational because of the fixation of the toxin in the substance of the brain, which the spinal fluid does not reach, and which would not be neutralized if it could be reached.

Great care must be used in the intravenous administration of this serum, as it appears that one, and possibly more, of our patients have been killed by it. It should be administered slowly, well diluted in a buffered solution, heated to the proper temperature. In one's haste to give the serum one

should not neglect a most important precaution—that is, the preliminary narcotization of the patient. The stimulus of injecting needles into a patient with this disease might otherwise easily result fatally. General anesthesia is said to make the occurrence of anaphylactic shock impossible, so that this should be remembered in sensitized, desperate cases.

The chief symptom to be combated is muscular rigidity, for it is this which kills the victim as a rule, through exhaustion or asphyxia. Consequently, drugs which cause relaxation are of the utmost importance. Morphine, chloral, and chloroform have been used for many years. Occasionally, other drugs have come into vogue for a while. For example, 25 per cent solution of magnesium sulphate used to be injected intraspinally; but it is nearly certain that two deaths in our series resulted from this procedure. Perhaps some of our most fashionable drugs of the present will some day belong to this discredited group. However, there seems to be a definite place for the use of tribromethanol[1] (Avertin). With this, it is possible to keep the patient narcotized for several days, and to maintain his nutrition and water balance meanwhile by continuous phleboclysis, perhaps with better chance of success than in the years before these measures were available. Mouth feeding is often impossible because of trismus. Injections of a local anesthetic into the masseters has been suggested as a means of overcoming this difficulty.

Whether or not the procedures mentioned above will stand the test of time, the fact remains as true today as when expressed in 1897 by Owens and Porter,[11] who conclude as I do now, in the same ungrammatical way, by saying, "An ounce of clean surgery is worth several pounds of serum therapy."

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# PERINEAL PROSTATECTOMY

## A SURVEY OF 67 CONSECUTIVE CASES

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THIS report includes a study of all perineal operations upon the prostate performed upon public ward patients, for a twelve-month period. It has been stated that a survey including both private and public patients does not give a fair estimate of the value of an operation, inasmuch as many such reports are in a large part composed of statistics on private patients who, as a rule, present themselves for treatment at a much earlier period in the course of their disease, and are consequently usually in much better condition.

Table I shows the diagnoses and operations as carried out in this series of cases. They were consecutive instances occurring in the general ward service, upon whom perineal operative procedures were performed. There were no deaths occurring in this series of cases.

TABLE I

ANALYSIS OF DIAGNOSES AND OPERATIONS IN 67 CASES*

| Diagnosis | Operation | Number of Cases |
|---|---|---|
| Benign prostatic hypertrophy | Perineal prostatectomy | 48 |
| Carcinoma of prostate (not extensive) | Radical operation for carcinoma of prostate | 1 |
| Carcinoma of prostate (extensive) | Conservative perineal prostatectomy | 9 |
| Prostatic abscess | Perineal incision and drainage | 4 |
| Abscess of seminal vesicles | Perineal incision and drainage | 1 |
| Tuberculosis of seminal tract | Radical operation for tuberculosis of seminal tract | 1 |
| Rupture of membranous urethra | Perineal repair of rupture of urethra | 1 |

* Two cases are omitted from this table but are discussed in detail in the body of the paper.

*Perineal Prostatectomy for Benign Prostatic Hypertrophy.*—Table II shows the age distribution in this group. The youngest patient was 46 years of age and the oldest 81 years. All of these cases were prepared by indwelling urethral catheter drainage, unless troublesome urethritis or a temperature developed. Indwelling catheter, however, was not used in five cases because of the relatively small residual, nor in cases with uninfected urine whose residual was perhaps slightly higher than those that are usually drained, all of whom, however, had good renal function. It was felt that

the danger of infection overbalanced what little advantage might be gained by drainage. In this respect, we are not in accord with those proponents of the suprapubic route, who believe that it is better to have infection present so as to gain, if possible, some degree of immunity prior to prostatectomy. We feel that the drainage afforded by a perineal wound along the path of an anatomic dissection does not offer the possibility of stasis, infection, and absorption that is undoubtedly present in the deep cavity of the suprapubic prostatectomy wound.

In this group there were five patients who had drainage other than by an indwelling urethral catheter prior to operation. Three of these, aged 81, 73 and 68, did not tolerate this procedure, owing to the presence of a pronounced urethritis with accompanying fever. In each of them, urethrostomy was performed through the bulbous urethra, thus allowing the insertion of a catheter through the perineum, directly into the bladder. Following this the temperature soon returned to normal, the patients improved and successfully underwent a perineal prostatectomy. The operation requires only a few minutes and is done under local anesthesia without producing any great discomfort. The objection raised, of course, is that one merely short circuits the urethra and that the deep or prostatic urethra, whose surface is already acutely inflamed, is still irritated by the presence of a catheter. We believe it is popularly thought that the prostatic urethra is usually the area of greatest absorption and therefore the site of the urethral reactions. This fact was recognized in doing this procedure, but we felt that inasmuch as the length of the urethra is greatly diminished by this operation, the drainage is thus greatly facilitated; that the course of the urethra from the perineal incision to the vesical neck is much straighter; also that the perineal opening permits a dependent point of drainage, and therefore the perineal urethrostomy had been efficacious in these cases. Because of their advanced age, and their general condition, a suprapubic cystostomy would have been a major undertaking in these three individuals, whereas perineal urethrostomy gave us our desired result without particularly upsetting the patient. Another important factor in this procedure is that each of the patients was much more comfortable with the perineal catheter than he would have been with the penile catheter.

Suprapubic cystotomy was carried out in one patient (B.U.I. 23525), aged 69. The residual urine was only 50 cc., but there was a large vesical calculus, and symptoms of prostatic obstruction. Rectal examination disclosed a benign prostatic hypertrophy, and cystoscopy revealed the presence of median and lateral obstruction. The phthalein output, although fair, was not what we considered normal, and inasmuch as he did not tolerate urethral catheter drainage, a suprapubic cystotomy was carried out for removal of the calculus, and drainage. Perineal prostatectomy was performed later. The fifth patient (B.U.I. 23684), who was drained otherwise than by an urethral catheter, was 68 years old, and had been in acute retention for about 20 hours. Several attempts had been made elsewhere to catheterize him, all of

which had been unsuccessful. There was marked tenderness in the region of the bulb and perineum, and urethral instrumentation showed that a false passage had evidently been produced. It was therefore deemed wise in this case to carry out suprapubic cystostomy.

*Method of Hemostasis in Perineal Prostatectomy.*—Hemostasis, in the cases of benign prostatic hypertrophy, was carried out by an approximation of the vesical neck to the prostatic capsule by suture. This method was used in every instance except two. One of these patients (B.U.I. 23956) was 46 years old, with a very small prostate, and hemostasis was obtained by a perineal tube and small iodoform pack. Hemostasis was effected in the second case (B.U.I. 23860) by the use of a Davis bag, after difficulty had been experienced in controlling the bleeding by suture. There were no cases of secondary hemorrhage in this group. An urethral catheter, as well as a perineal tube, was inserted into the bladder at the time of operation, the perineal tube serving as a means of removing clots from the bladder, if necessary. This is usually removed within 24 hours. The urethral catheter is left in varying lengths of time, from 7 to 14 days, according to its being tolerated. One case was closed with the perineal tube alone, as there had been an urethritis previously. The suture technic apparently lowers the incidence of embolism. The explanation for this, we believe, in contradistinction to the cases where a bag or pack is used, is the fact that by means of the suture method only a minimal amount of tissue is compressed and devitalized, so that the resultant necrosis of tissue and extent of thrombosis of the pelvic vessels are materially lessened. In only one case in this group was there suggestion of a pulmonary embolism, as evidenced by chest pain and fever, but this was not substantiated by roentgenologic examination. The absolute control of hemorrhage, with an anatomic restoration of the prostatic bed, as afforded by the suture technic, warrants the use of this procedure.

## CASE REPORTS OF INSTANCES WITH DEFINITELY IMPAIRED RENAL FUNCTION

**Case 1.**—J. G., (B.U.I. 23669), aged 68, was admitted with a history of obstruction to urination for the past two years. During the past six months he had biweekly catheterizations. In the interim he had marked difficulty, voiding frequently, in small amounts and with a very weak stream. Two days before admission, nausea and vomiting occurred, and for the past nine months he had also had severe headaches and attacks of dizziness.

*Examination.*—Blood pressure, 202/104; temperature, 99.4° F.; pulse, 84; respirations, 20. The patient's clothing was saturated with the odor of urine, he was disoriented, and moderately emaciated. He could pass only a few drops of urine at a time. The bladder was distended to the level of the umbilicus. Rectal examination showed moderate benign prostatic hypertrophy. An urethral catheter was inserted and decompression was carried out over a period of 48 hours. Blood urea 140 mg. per 100 cc. on admission, and the phenolsulphonephthalein determination following decompression showed an excretion of only 3 per cent in the first 30 minutes, with a total of 17 per cent in two hours, the appearance time being eight minutes. This patient had definite cardiovascular disease with a greatly enlarged heart, and marked peripheral arteriosclerosis. He received adequate dosage of digitalis and remained on catheter

drainage for 56 days prior to operation. Blood urea and phthalein excretion showed very little improvement, however, as at the end of this time the blood urea was 84 mg. per 100 cc., the phthalein excretion showed only 10 per cent in the first 30 minutes, with 25 per cent two hour total and six minutes appearance time. However, it was felt that the patient had improved as much as possible, his renal function was stabilized, therefore perineal prostatectomy was undertaken under 50 mg. of novocain, spinal anesthesia. The postoperative course was uneventful. The urethral catheter was well tolerated and was not removed until the twelfth day postoperatively. The perineal wound was well healed on the thirtieth postoperative day. At discharge, blood urea was 80 mg. per 100 cc., and phenolsulphonephthalein test was unchanged. Patient was voiding normally with good control. He appeared clinically well in spite of his poor renal function.

**Case 2.**—E. W., (B.U.I. 23467), aged 60, gave a history of urinary obstruction for six years. The patient had a dribbling incontinence if he went longer than two hours without voiding. There was definite diminution in the size and force of the urinary stream. Residual urine 325 cc. Blood urea 72 mg. per 100 cc. A phenolsulphonephthalein test showed 16 minutes appearance time, only a trace being excreted in the first 30 minutes, and 21 per cent at the end of two hours and 16 minutes. Blood pressure, 214/116. There was some irregularity in the rhythm of the heart, and definite thickening of the peripheral vessels. Rectal: A moderately enlarged, benign prostate was present. The patient was placed on indwelling urethral catheter drainage, but the blood urea remained between 88 and 116 mg. per 100 cc., and the phthalein excretion did not change. After 44 days it was felt that no further improvement could be gained by continued drainage, and inasmuch as the patient's renal function was apparently stabilized, a perineal prostatectomy was undertaken. The postoperative course was uneventful, with the exception of a *B. proteus* wound infection, which did not cause breakdown of the wound. The patient voided on the seventeenth postoperative day and the wound was completely dry on the twenty-seventh postoperative day. Three and one-half months following operation he stated that he "felt quite well," was voiding only once, and occasionally twice, at night. The blood urea was 68 mg. per 100 cc.

As shown in the tabulation of the age distribution of these cases, nine were in the group of 71 to 75, inclusive, and there was one of 80, and one of 81.

TABLE II

AGE DISTRIBUTION IN THE FORTY-EIGHT CASES OF PROSTATIC HYPERTROPHY

| Age Group | 46–50 | 51–55 | 56–60 | 61–65 | 66–70 | 71–75 | 76–80 | 81–85 |
|---|---|---|---|---|---|---|---|---|
| Number of Cases | 1 | 2 | 4 | 10 | 20 | 9 | 1 | 1 |

Average age: 66.5 years.

## CASE REPORTS OF THE TWO OLDEST PATIENTS

**Case 1.**—W. M. (B.U.I. 23536), aged 81, gave a history of urinary difficulty of ten years' duration. Five years previously a transurethral procedure was attempted elsewhere, but introduction of the resectoscope was found impossible. Following this, the patient continued frequent voiding of small amounts of urine, accompanied by much straining. There was also a history of auricular flutter over the past 20 years, and this was observed several times during his hospitalization.

*Examination.*—Temperature, pulse and respirations were normal. Blood pressure, 180/110. The heart showed moderate enlargement and there was marked sclerosis of the peripheral vessels. The bladder was about four finger-breadths above the sym-

physis. Rectal: An enormously enlarged, benign prostate. Indwelling catheter was inserted and decompression carried out. Following this, the patient developed a very severe urethritis and systemic reaction, temperature reaching 103° F. Perineal urethrostomy was performed, which resulted in a return of the temperature to normal, but he appeared quite weak, and although he had a fairly normal phthalein and blood urea, he was allowed to remain on drainage 15 days prior to prostatectomy. During this period the patient had several attacks during which the pulse would reach 160 and he would become slightly dyspneic and apprehensive. Perineal prostatectomy was performed under 50 mg. novocain, spinal anesthesia. The patient had an attack of tachycardia just prior to operation, pulse was 110 at the time of operation, and during operation the blood pressure became imperceptible and intravenous glucose was administered, with effective result. He developed a *B. proteus* wound infection, causing a breakdown of the wound, which greatly retarded his convalescence. Bilateral vasectomy had been performed as routine on practically all of these cases, but, unfortunately, it was not carried out on this individual and he developed a suppurative epididymitis which involved the testis and necessitated orchidectomy. The perineal wound was not healed until the seventy-sixth postoperative day, but on discharge he had very good urinary control and was feeling quite well.

**Case 2.**—J. C. (B.U.I. 23831), aged 80, was admitted with a history of urinary obstruction and difficulty of four years' duration.

*Examination.*—Temperature, 104.4° F.; pulse, 146; respirations, 24. Chest showed cardiac enlargement, heart sounds were very poor and irregular. There were a few râles at both bases. Liver was palpable below the costal margin and there was a moderate amount of edema of the lower extremities. Bladder was midway to the umbilicus. Rectal: A moderately enlarged benign prostate. An indwelling catheter was inserted and decompression carried out over a period of 24 hours. After several days' rest in bed, the temperature and pulse returned to normal. The blood urea and phenolsulphonephthalein excretion showed good kidney function. There being some doubt as to the degree of prostatic obstruction present, the retention catheter was removed, but the patient continued to have difficulty in voiding, and he was found to have 500 cc. residual. Cystoscopy showed lateral and median lobe hypertrophy present, as well as the usual bladder signs of obstruction. Perineal prostatectomy was performed, a small fibrous prostate being removed. Urethral catheter was removed on the sixth postoperative day, the wound remaining dry from the ninth to the twelfth, and then leaked a small amount until the sixteenth postoperative day, after which it healed permanently. At the time of discharge, the patient had very good urinary control, and his general condition was excellent.

The average healing period in cases of perineal prostatectomy for benign prostatic hypertrophy was 24.8 days. This included three cases of severe *B. proteus* wound infection, which caused the wound to break down, in which the healing period was 76, 64, and 56 days, respectively. If these cases are not included, the average period for healing in the remaining 45 cases was 22.1 days.

*Radical Operation for Carcinoma of the Prostate.*—This procedure was performed on only one patient, E. C. (B.U.I. 23695), aged 53 years, who had suffered from frequency and difficulty of urination for about five months prior to admission. Rectal examination showed very definite carcinoma of the prostate, apparently confined well within the prostatic capsule. Residual urine, 50 cc. Renal function, good. The radical operation was done under spinal anesthesia. The wound had healed at the end of 16 days. On dis-

charge the patient had some slight difficulty in controlling his urine when coughing or sneezing, but on examination five months later, his control was good.

*Conservative Perineal Prostatectomy for Extensive Carcinoma of the Prostate.*—There were nine cases in this group. The ages varied from 50 to 73 years. Examination in each case disclosed an extensive carcinoma of the prostate in which there was no hope of a radical cure.

*Prostatic Abscess.*—There were four cases of prostatic abscess and one case of abscess of the seminal vesicles which were drained by the perineal route.

*Perineal Repair of Rupture of Urethra.*—There was one case (B.U.I. 23627), a steel worker, who received fractures of both lower extremities, pelvis and lumbar vertebrae and a rupture of the membranous urethra at the apex of the prostate, as the result of a fall. An immediate suprapubic cystotomy was performed. Attempts at retrograde catheterization being futile, a perineal intervention had to be postponed until the fractured vertebrae were healed. This, therefore, was done at a later date, with excellent result.

*Radical Operation for Tuberculosis of the Seminal Tract.*—There was one case (D. S., B.U.I. 22844) in this group, in which nephrectomy had been done previously for tuberculosis. Examination on admission revealed a definite tuberculosis of the epididymis, seminal vesicle and prostate. The perineal wound had healed *per primam* by the end of two weeks.

There was one case (F. N., B.U.I. 23599) of benign prostatic hypertrophy in which, during the course of the perineal dissection, an injury occurred to the rectum. It was thought that this was produced by too forceful posterior retraction. Enucleation had not been begun. The urethrotomy was closed and the rectal injury repaired in two layers. Suprapubic cystostomy was done immediately. At a later date, suprapubic prostatectomy was successfully carried out, without the complication of a perineal urinary fistula. There is another case (H. M., B.U.I. 23832) previously mentioned, in which conservative perineal prostatectomy was attempted but, because of inability to dissect the rectum away from the posterior aspect of the prostate, due to marked carcinomatous involvement, the operation was not completed. The perineal wound was closed, healed *per primam*, and a transurethral resection was carried out later with relief of the obstruction.

## SUMMARY

(1) A series of 67 consecutive perineal operations on the prostate, on public ward patients, is reported without a death. This constitutes every case admitted to the public wards, without an exception, receiving a perineal operation, during a period of 12 months.

(2) Suture of the vesical neck to the prostatic capsule decreases morbidity as well as mortality.

(3) The average healing period in cases of perineal prostatectomy for benign hypertrophy was 24.8 days. This included three cases of severe wound infection with a breakdown of the wounds. If these cases are omitted the average period for healing in the remaining 45 cases was 22.1 days.

I am indebted to Dr. Hugh H. Young, whose principles in the management of prostatic lesions have been followed.

# RHABDOMYOSARCOMA OF THE NECK

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Tumors of the spinal muscles of the body wall and extremities are extremely rare. This rarity of tumor formation is probably dependent upon the early differentiation of these structures in the embryo. According to Keith[1] no more new fibers are formed in skeletal muscles after birth, muscular development occurring as a result of the enlargement of the preexisting fibers. Geschickter[2] states that muscle tumors are not uncommon in the smooth muscles of the genito-urinary organs. In the musculature of the digestive tube, heart and large blood vessels, derived from the splanchnopleura, tumor instances are more unusual. New growths here, however, are neither as rare as in the voluntary skeletal muscles nor as common as in the musculature of the genito-urinary organs. Geschickter has collected a number of cases of muscle tumors from the literature, and has reported those occurring at the Johns Hopkins Hospital. According to Klinge,[3] only nine acceptable cases of rhabdomyoma of the body musculature had been described up to 1926. Geschickter reports two additional instances of rhabdomyomata of the voluntary muscles; one of these was in the cervical region of a child and the other was situated in the leg. It is questionable whether the term rhabdomyoma should be used in describing tumors of the voluntary muscles because of their undoubted malignant tendency. Hirsch[4] reports a case of rhabdomyosarcoma of the spermatic cord and has enumerated the other tumors of this type which have appeared in the literature.

## CASE REPORT

Mrs. L. J., white, aged 40, was referred to the Tumor Clinic of the Norton Memorial Infirmary March 28, 1932, by Dr. Lilliard of Lawrenceburg, Ky. For 11 years she had noticed a small swelling on the right side of the neck which had slowly enlarged. For the past four years her gait had been unsteady and her vision failing. She had had no headaches and otherwise the history was unessential. She has two children living and well. There was no history of malignancy in the family except that a cousin died from a cancer of the neck following the removal of a cystic tumor.

*Examination.*—Patient is a well developed and well nourished white female. The head is normal in size and shape and there is no tenderness over the sinuses. The pupils are equal and react normally to light and accomodation. There is some horizontal nystagmus and no paralysis of the ocular muscles. The ears, nose, mouth and throat are negative.

There is a large tumor mass on the right side of the neck which is firm and not tender. It is approximately 10 by 6 by 5 cm. and is fixed. The skin over it is normal in appearance and is not attached to the tumor. The thyroid is not enlarged. The

lungs are normal, heart regular, good tone, no murmurs. Blood pressure: systolic 130/90. Pulse 80. Abdominal and pelvic examination entirely negative.

The knee jerks are hyperactive and there is a bilateral Babinski. No ankle clonus could be elicited. The abdominal reflexes are present The Rhomberg is positive, the patient falling towards the right. She walks with a very unsteady gait and with a tendency to fall to the right. There is no disturbance of sensation. Examination of the eyegrounds showed the disks to be pale but distinct in outline. The blood vessels were or normal size and there were no hemorrhages or scars in the retina. Urine negative. Red blood cells, 3,890,000; Hemoglobin, 70 per cent; white blood cells, 7,900. Differential showed a slight increase of neutrophilis, otherwise normal.

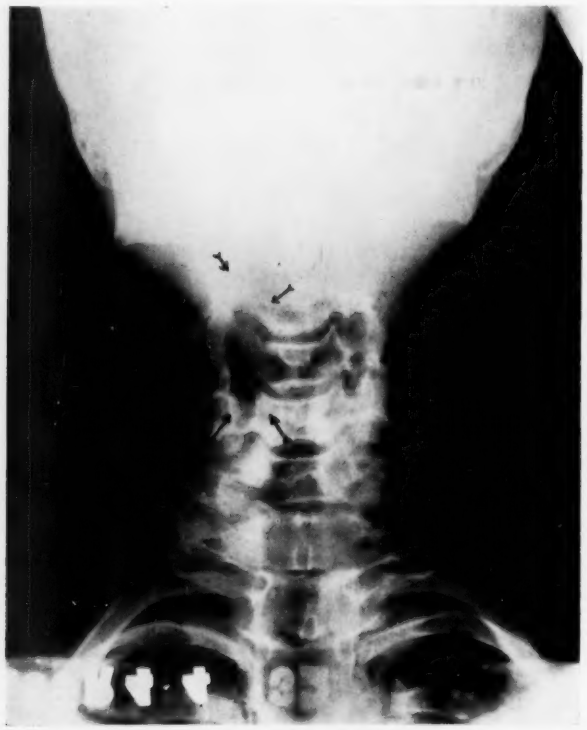

FIG. 1.—The arrows point to area of third, fourth and fifth cervical vertebra destroyed by the growth.

*Roentgenologic Examination* by Dr. J. C. Bell.—Stereoscopic films of the cervical spine made in anteroposterior and lateral positions showed defects in the laminae of the third, fourth and fifth cervical vertebrae on the right side and apparently in the articulating facets of these vertebrae as well, especially the third and fourth (Fig. 1). The body of the fifth cervical vertebra does not seem to be quite as dense as the others but no other evidence of destruction is seen. The anterior margin of the first vertebra is peculiar, there being a sharp projection extending up toward the base of the skull. This is very sharply defined and probably is not of clinical significance. There is marked swelling of the soft tissues lateral to the defects in the vertebrae.

It seems evident that there is a destructive lesion arising within the cord or about the ends of the nerve roots. The destruction is probably secondary to this. The defects look as if they were due to pressure rather than to a metastatic growth. The fact that the destruction involves chiefly the right lateral portions of the vertebrae

suggests that it is due to a tumor in the nerve roots or in the structures surrounding the cord rather than to something starting in the cartilage or bone. No other abnormalities are noted.

Operation March 29, 1932. Under ethylene-ether anesthesia a four inch incision was made over the tumor mass on the right side of the neck, exposing the muscles on the posterolateral aspect. The muscles were split and the tumor exposed. It was about the size of an orange, encapsulated and had the appearance of being cystic. The overlying muscles were dissected off the tumor and it was then found that the growth was firmly attached to the third and fourth cervical vertebrae. As the size of the tumor obstructed vision in to the deeper parts of the operative field the tumor was opened and about three ounces of thin brown fluid evacuated. Within the cavity there were several projections about 5 by 25 Mm. having the appearance of muscle tissue. Each projection ended in a blunt conical tip. The remainder of the tumor was solid, and composed about one-half of the entire mass. The tumor itself was then freed down to

FIG. 2.—The cavity contained fluid in which there was much old blood. Numerous bundles of tissue can be seen, one of which is bulbous. These may be attempts at muscle formation.

the cervical vertebrae and it was found that the third, fourth and fifth vertebrae had been eroded and that the tumor mass had grown into the spinal canal. On removing the tumor there was seen what appeared to be tumor tissue within the spinal canal. As much of this as possible was removed and the incision closed with two rows of interrupted sutures. There was some oozing from the depth of the wound which was controlled by a small gauze tampon.

The patient made an excellent operative recovery and left the hospital April 5, 1932. The reflexes were still hyperactive but the patient was walking much better and the gait was steady.

*Pathologic Examination* by Dr. A. J. Miller: *Gross.*—The specimen consists of a lobulated mass weighing 80 Gm. It is encapsulated. The color is grayish-pink and it has a translucent character. The sectioned surface reveals several cavities, evidently formed by necrosis. They contain dark red, serous fluid that has the characteristics of old blood. On the surface of the tumor and also in the sectioned surface there are bundles of tissue of various sizes and lengths. Some of these have broad ends and long slender tails making them shaped like a tadpole (Fig. 2).

*Microscopic.*—Sections from various places show a rather uniform structure. There is a parenchyma consisting of very large to small masses of cytoplasm which stains densely with eosin and has longitudinal filaments, but no cross striations. In many areas these large cells contain 8 to 15 nuclei. These cells resemble muscle and are supported by a delicate connective tissue stroma (Fig. 3). Blood vessels are few, but well formed. Mitoses are not seen, but numerous nuclei are apparently in direct division. They are only moderately atypical and vary but little in structure. Invasion cannot be demonstrated. With the aid of the history and the operative report of a lack of limitation, the tumor is classified as of low grade malignancy.

The parenchymal cells are apparently muscle cells, although no cross striae are seen. The multinuclear character would suggest skeletal muscle origin, rather than smooth muscle (Fig. 4); although the latter is possible. There is no evidence of a fetal rest origin, other than the presence of the tumor; therefore, the regional skeletal muscle is suggested as the source.

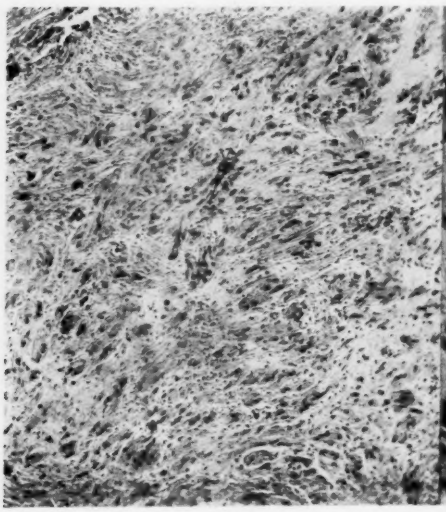

FIG. 3.—There are large masses of eosin staining cytoplasm with multiple nuclei and supported by a delicate connective tissue stroma.

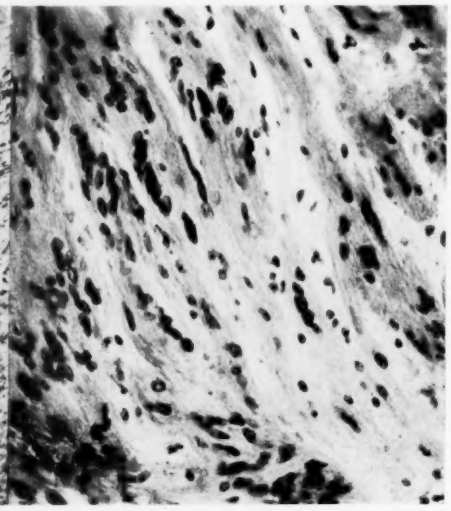

FIG. 4.—There are large, multinucleated masses of cytoplasm with longitudinal fibrils. No cross striation is seen. Between these large cells is a delicate connective tissue stroma. Ph. A. and H. stain.

Sections indicate that the strand-like character of the tumor is the result of an attempt at muscle bundle formation. The expanded ends result from a lack of attachment.

The tumor probably will not metastasize, but be persistent in local recurrence. Resistance to radiation therapy is high for the parenchymal cells, and there are too few blood vessels to expect much response from radiation damage to them. *Interpretation.*—Rhabdomyosarcoma.

The patient was again examined May 1, 1932, because of the appearance of a small tumor at the site of the previous operation. She also complained of some pain in the right shoulder and arm. Pulses were equal and regular. Blood pressure 145/100. Reflexes normal. No Babinski. Rhomberg negative.

She was reoperated upon May 2, 1932. A four inch incision was made along the anterior border of the right sternomastoid muscle. The muscle was retracted outward and the tumor exposed. It was found that the growth was coming out of the cleft on the lateral aspect of the third, fourth and fifth cervical vertebrae. This cleft was

large enough to admit the tip of the finger. The tumor, and as much as possible of that in the spinal canal were removed and 50 mg. of radium, screened with silver, and 1 Mm. of brass, was inserted into the clefts of the cervical vertebrae through which the tumor protruded. The radium was held in place by suture and allowed to remain for five hours. The wound was closed with interrupted stitches.

*Pathologic Examination* by Dr. A. J. Miller: *Gross.*—Specimen consists of a spherical mass of tissue weighing 4 Gm. It is encapsulated. The color is grayish-pink and slightly translucent. There are a few bundles of tissue, but this character is not so marked as in the previous specimen. There is some old blood pigment.

*Microscopic.*—The structure is identical with that of the previous specimen. There are, however, fewer large, multinucleated cells, and they are more atypical. This is possibly the result of growth from the less differentiated cells which are more invasive and grow more rapidly. *Interpretation.*—Rhabdomyosarcoma.

The patient made an excellent operative recovery and left the hospital May 7. She was instructed to report in three weeks to Dr. C. D. Enfield for roentgen therapy. This treatment was begun on May 24, 1932, and was continued for six treatment days.

The patient was given two series of roentgen treatments, employing the same physical factors consisting of 160 P.K.V., 8 Ma., 50 cm. distance, ¼ Mm. of copper and 1 Mm. of aluminum filtration. In each series the patient was radiated through three fields, the right anterior cervical region, the right lateral cervical, and the posterior cervical areas. The total radiation consisted of one hour to each field, corresponding to 1,320 r units, or a total of 3,960 r for the three fields.

The second series, employing the same factors except that the time was 45 minutes to each field, was started on July 5 and terminated in five treatment days with total radiation of 945 r to each field, or a total of 2,835 r units.

We have seen this patient on several occasions during the past three years. Our last report as to her condition was received from her family doctor August 9, 1935. He states that she is perfectly well, has no headaches, no disturbance in gait and that there has been no sign of any reappearance of the tumor.

Rhabdomyosarcomata are sufficiently rare to warrant adding one more instance to the literature of muscle tumors. This case is of further interest in that it is the only one, of which we have knowledge, that has not succumbed to the disease, although sufficient time has not elapsed to consider it a cure. It is furthermore of interest in that it demonstrates what can be accomplished by intensive radiation of tumors which are usually considered resistant to such forms of therapy.

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# THE SURGICAL TREATMENT OF TUMORS OF THE PERIPHERAL NERVES

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THE multiplicity in types of tumors of the peripheral nervous system and the diversity with which these lesions are found in the face, neck, extremities, thorax and abdomen, have given rise to an extensive literature on descriptions of such growths and their proper surgical treatment. The different forms of these neoplasms occurring in widely scattered parts of the body call for operative procedures of great variety, and often tax the surgeon's ingenuity in treating them. There are, however, certain general principles which can be set forth to guide the treatment of nerve tumors as they are attacked at various sites and in the following presentation we briefly review some of the accepted ideas on technical procedures, choice of operations, and postoperative care. We have purposely avoided discussion of the nerve sheath tumors arising in the abdomen, principally the stomach, for the problems of removal are essentially the same as those for other intra-abdominal neoplasms. The nerve sheath tumors of the mediastinum and thoracic cage necessitate a detailed and rather specialized technic which is beyond the scope of the present communication, but valuable contributions have been made to this field, particularly by Harrington[10] and Heuer.[11] In the following discussion* some of the more commonly employed procedures are described first, leaving until later other considerations such as selection of operation and postoperative care.

*Preoperative Considerations.*—The anesthetic employed need give little concern, for a wide variety can be chosen from if there are no complicating factors. Ether, avertin-ether, or nitrous oxide-oxygen-ether all serve admirably. Spinal anesthesia is preferable for operations upon the legs. One should not attempt, however, to remove one of these neoplasms under local conduction anesthesia, for injection of novocain directly into a large nerve trunk is too apt to produce injury and subsequent neuritis.

The armamentarium need include but few special instruments. A blunt end nerve hook will be found desirable in handling small trunks. Delicate smooth and mouse tooth forceps are essential. Silver clips may be found useful for controlling bleeding vessels on the surface of or in the substance of a nerve. Fine silk is far superior to catgut if repair or end-to-end suture of a nerve trunk is to be done. Black silk of size 1 is suitable, but if this is not available, No. 4 (A silk) can be split into its three separate strands

* Three of the cases cited here for illustrative purposes were operated upon by Dr. Harvey Cushing, Dr. David Cheever and Dr. John Homans to whom we make grateful acknowledgment.

and one of these will be of correct diameter and strength. Commercially prepared blood vessel suture silk is excellent. The needles should be small, curved, semi-curved and straight, with closed eyes. These can be threaded beforehand and if sterilized in oil or waxed they will be found to slip more easily through nerve tissues if repair is performed.

Operative Procedures.—*Excision of Tumor from Within Trunk Without Division of Functionally Active Fibers.*—If the tumor is a benign neurofibroma or neurilemmoma, it is permissible to shell it away from the nerve trunk. It is of prime importance to recall that the benign nerve sheath tumor (unassociated with von Recklinghausen's disease) grows in such a way as

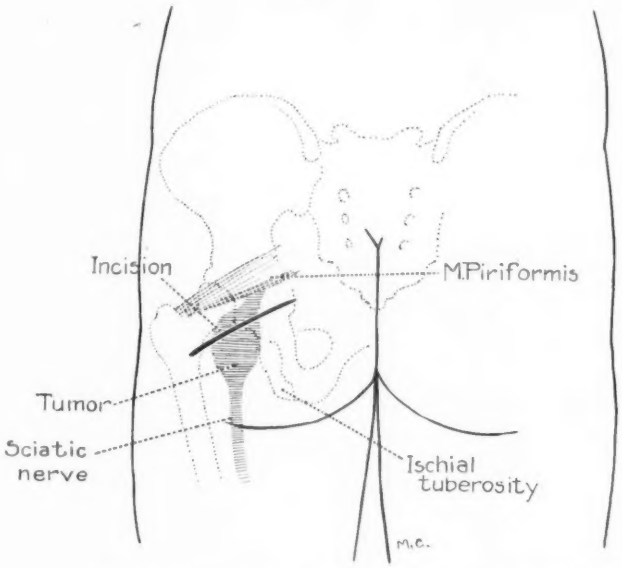


Fig. 1.—Schematic drawing to show position of a benign perineurial fibroblastoma of the left sciatic nerve from a case treated as indicated in Figs. 2, 3 and 4.

to push the nerve trunk to one side or to expand it. The nerve proper does not, therefore, directly enter the mass but is displaced laterally or is pushed out so as to completely surround the neoplasm. Thus one always finds a good line of cleavage which permits dissection of the tumor away from the nerve without severing its fibers or disturbing their functional integrity. When the nerve lies toward one side, it can, of course, be dissected off with ease. If, however, the nerve completely surrounds the mass, the covering fibers must be incised longitudinally to permit withdrawal of the central growth. Figs. 1 to 4 illustrate such a treatment in removal of a lemon-sized perineurial fibroblastoma of the sciatic nerve in one of our cases. After this dissection the nerve may be frayed out or indeed may consist of little more than a flabby, collapsed shell, but it can be dropped back into the wound and there may be little or no sensory or motor disturbance in the area which it supplies. If longitudinal incision has been made in the nerve trunk to permit

Annals of Surgery
September, 1936

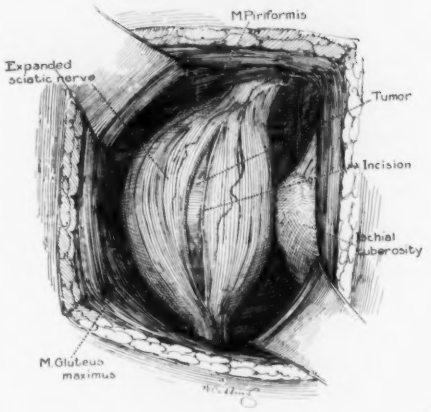


FIG. 2.—Operative exposure of a perineurial fibroblastoma of the sciatic nerve in the buttock (compare with Fig. 1). The gluteus maximus muscle has been split and the edges retracted. Fibers of the sciatic nerve are expanded around the neoplasm. Incision is made parallel to the nerve fibers in order to reach the central mass.

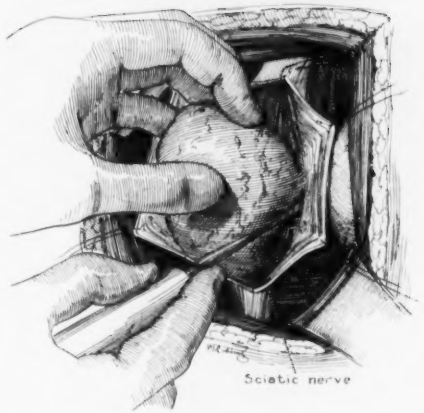


FIG. 3.—Removal of a benign nerve tumor from the sciatic nerve (see Figs. 1 and 2). The sciatic nerve is split open and its edges gently retracted with silk stitches. The neoplasm is shelled out from its bed by blunt dissection.

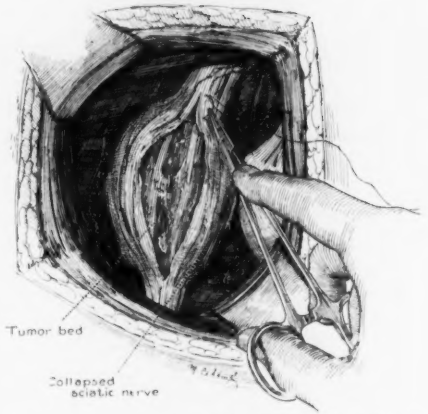


FIG. 4.—Repair of nerve trunk following extirpation of a neurofibroma (see Figs. 1 to 3). The separated edges of the nerve are lightly approximated by a few silk stitches. The nerve, though stretched and flabby, remains functional.

enucleation of a tumor, the edges of this defect can now be brought together with a few interrupted silk sutures (Fig. 4). Such approximating sutures should be of the finest silk and loosely tied so as not to injure apparently healthy nerve fibers.

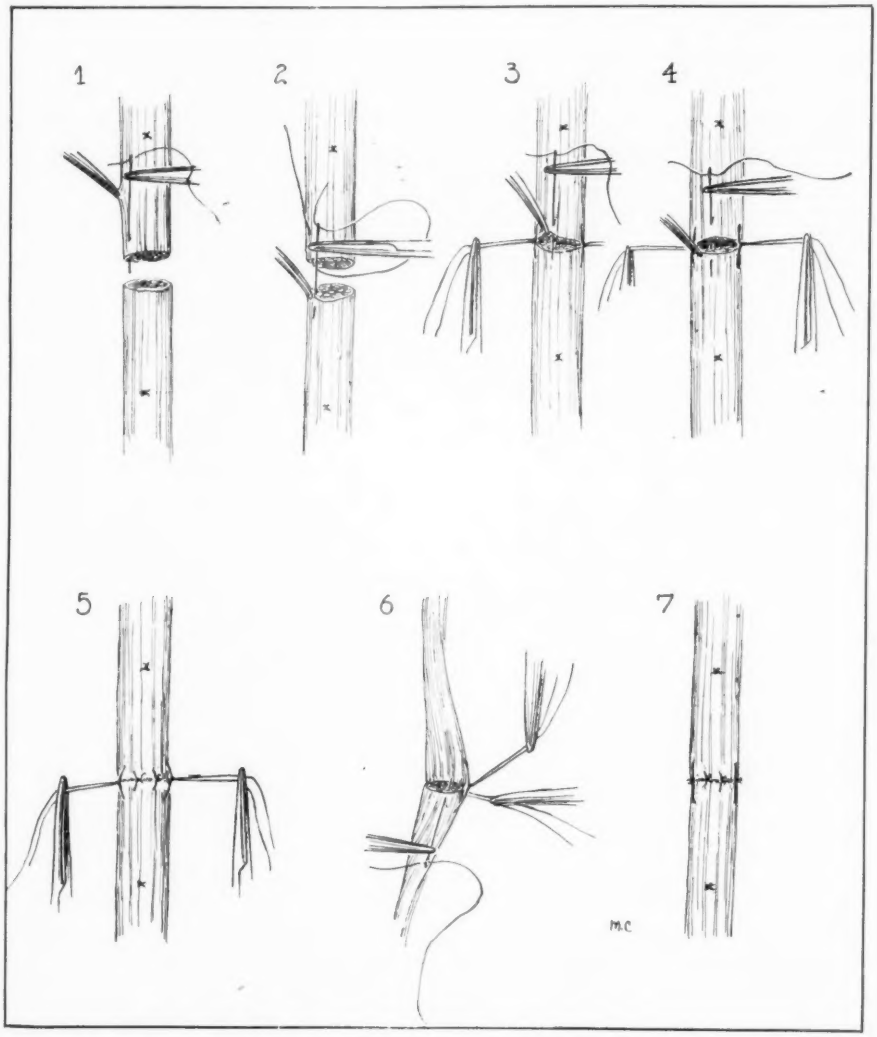


FIG. 5.—Method of end-to-end nerve suture. Note in all of the sketches the small identification knots (placed before the nerve was divided) which serve to prevent rotation of the proximal or distal segments. (1) Fine straight needle passed through epineurium. (2) Stitch carried through covering of opposing nerve end. (3 and 4) First two (diametrically opposite) stitches left long and snapped for purposes of handling the nerve. Intermediate sutures being placed. (5) Sutures completed on front of nerve. (6) Nerve rotated for placing of posterior sutures. (7) Repair completed.

*Excision of Tumor with Division of Nerve.*—The second and less commonly employed method of nerve tumor excision is to make a clean and complete resection of the mass so as to include a portion of nerve proper. If the nerve which is thus surgically severed is a small subcutaneous one or is

an unimportant branch, no attempt at repair is necessary. If, however, the trunk is large, it is definitely the duty of the surgeon to attempt an immediate restoration by end-to-end sutures. Such a reconstruction is relatively easy to perform, but care and delicacy must be exercised to establish a nice approximation of the divided nerve ends in order to reduce the possibility of subsequent neuroma formation and to give the best possible chance for reestablishment of nerve function.

A number of methods have been described for end-to-end nerve suture and the steps indicated in Fig. 5 represent an acceptable operation. The ends of the nerve must be cut cleanly at right angles to the long axis of the trunk. Two guy sutures are then placed (Fig. 5). These sutures include 2 or 3 Mm. of the nerve end and pass through the ensheathing epineurial coat only, for this is the strongest portion of the nerve and must be employed to give

FIG. 6.—Schematic cross-section of median nerve at the midarm level (from Kraus and Ingham) showing position of bundles as determined by electrical stimulation of this level. (1) Pronator radii teres; (2) flexor carpi radialis; (3) palmaris longus; (4) flexores digitorum; (5) flexor pollicis; (6) pronator quadratus.

FIG. 7.—Schematic representation of funicular topography of median nerve at midforearm level (from Kraus and Ingham). (1) Sensory; (2) opponens pollicis; (3) abductor pollicis; (4) lumbricales.

strength to the suture line. Under no circumstances should these sutures pass diametrically through the nerve, for in such a location they tend to buckle the nerve union and to impede the progress of regenerating axis cylinders. These first two stitches are left long and are used for traction in order that the nerve may be held and rotated during placement of the remaining sutures (steps 5 and 6, Fig. 5). Babcock[1] has devised a clamp by means of which the two ends of the nerve may be held by small piercing wires and thus be brought together and handled during the steps of suturing. With the ends of the nerve drawn together, additional interrupted sutures may now be placed around the entire periphery of the nerve, the total number varying from four or five in a small trunk to as many as 12 or 15 in a large nerve such as the sciatic. The nerve should be picked up with the finest of forceps, and only the outer covering need be grasped during the manipulations. The

nerve tissue tends to dry quickly and hence should be kept moist with saline while it is exposed.

When any nerve is divided and repaired by end-to-end suture, great care must be taken to prevent rotation of the two cut ends when they are sutured. It has been shown that fibers coursing to muscle groups are isolated into more or less segregated portions of a nerve trunk (Figs. 6 and 7), and hence

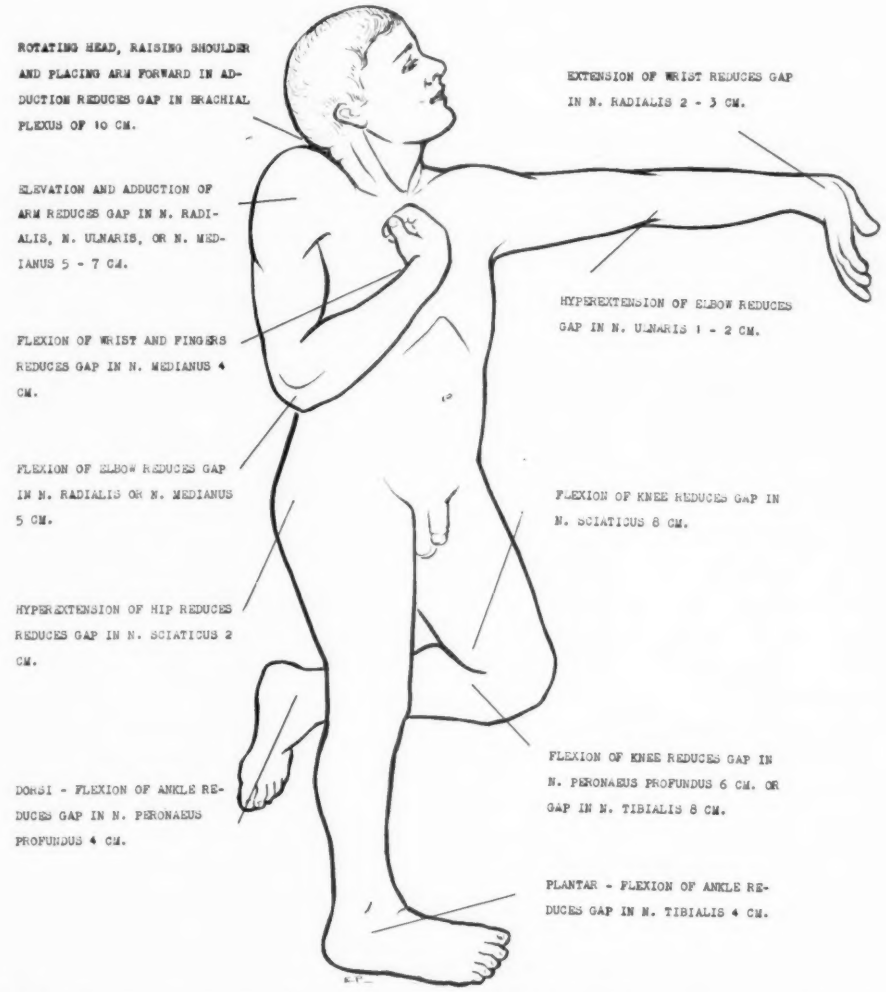
ROTATING HEAD, RAISING SHOULDER AND PLACING ARM FORWARD IN ADDUCTION REDUCES GAP IN BRACHIAL PLEXUS OF 10 CM.
ELEVATION AND ADDUCTION OF ARM REDUCES GAP IN N. RADIALIS, N. ULNARIS, OR N. MEDIANUS 5 - 7 CM.
FLEXION OF WRIST AND FINGERS REDUCES GAP IN N. MEDIANUS 4 CM.
FLEXION OF ELBOW REDUCES GAP IN N. RADIALIS OR N. MEDIANUS 5 CM.
HYPEREXTENSION OF HIP REDUCES REDUCES GAP IN N. SCIATICUS 2 CM.
DORSI - FLEXION OF ANKLE REDUCES GAP IN N. PERONAEUS PROFUNDUS 4 CM.
EXTENSION OF WRIST REDUCES GAP IN N. RADIALIS 2 - 3 CM.
HYPEREXTENSION OF ELBOW REDUCES GAP IN N. ULNARIS 1 - 2 CM.
FLEXION OF KNEE REDUCES GAP IN N. SCIATICUS 8 CM.
FLEXION OF KNEE REDUCES GAP IN N. PERONAEUS PROFUNDUS 6 CM. OR GAP IN N. TIBIALIS 8 CM.
PLANTAR - FLEXION OF ANKLE REDUCES GAP IN N. TIBIALIS 4 CM.

FIG. 8.—Diagrammatic representation of the amount of nerve defect which may be overcome by movement of joints as indicated (after Babcock).

an attempt must be made to join the two ends so that the bundles of the proximal portion will lie in apposition to the corresponding funiculi of the distal end. This will insure the best possible chance for the regenerating axones to grow out into their proper peripheral distribution. A good way to guard against rotation of the two ends is to place two small silk ties on

one surface of the nerve before excision of the tumor. These knots then serve as identification sutures during the various stages of end-to-end suture (Fig. 5).

The great size attained by many of the peripheral nerve tumors may appear to militate against excision of the nerve trunk for fear of not being able to subsequently bring the divided ends together. The general rule may be stated, however, that one never encounters a nerve tumor so large that removal of the involved nerve trunk prohibits bringing together of the divided nerve ends. The only exceptions to this are provided by neoplasms of the thorax and, rarely, by some of those arising in the neck. In the arms and legs, however, it is remarkable what lengths of nerve gaps may be closed by employing one or several of the following important procedures:

(1) The normal elasticity of the nerve allows it to be stretched for lengths varying from 1 to 2 cm., depending upon the nerve under consideration. This small but important degree of slack may be utilized without placing undue tension on the suture line.

(2) The proper position of a limb adds a considerable additional available length which may be employed in reducing a nerve gap. Babcock[2] has had a most extensive experience with peripheral nerve injuries and has employed this method with unusual success, reducing the nerve gaps in various nerves by the maximum amounts indicated in Figure 8.

(3) Additional lengths may be obtained in a nerve trunk by rerouting. Not all nerves lend themselves to this procedure, but a familiarity with the technic will occasionally permit a reduction of a nerve gap not obtainable by any other operation alone. The ulnar, median, radial and tibial nerves offer the best branches for this procedure. The ulnar nerve may be loosened from its bed at the elbow and by changing its position so as to make it lie in front of the internal epicondyle of the humerus, an additional 2 cm. may be gained. The radial nerve may be unwrapped from the humerus and upper arm muscles, and by displacing it to lie on the anteromedial aspect of the upper arm an additional 3 to 4 cm. may be added to its length. The median nerve can be displaced from its deep bed and by raising it to a position superficial to the forearm muscles a length of 2 cm. can be gained. In performing these procedures great attention must be paid to the twigs supplying surrounding muscles and these individual fibers may be stripped back along the nerve so that they take origin higher up than they did formerly. By this procedure these muscle branches are damaged only a negligible amount. The tibial nerve can be displaced to a position in front of the internal malleolus, an additional 2 to 3 cm. being gained thereby. Rerouting of a nerve necessitates very liberal exposure and unless one is prepared to make an unusually long incision, the operation is doomed to failure.

Table I indicates the maximum amount of gap which may be reduced in various nerves (Babcock) by taking advantage of the normal nerve elasticity by proper position of the neighboring joints, and by rerouting.

TABLE I

MAXIMUM GAPS IN PERIPHERAL NERVES IN WHICH END-TO-END SUTURE IS POSSIBLE (AFTER BABCOCK)

| | By Slack and Elasticity | By Joint Position | By Rerouting | Totals |
|---|---|---|---|---|
| | cm. | cm. | cm. | cm. |
| Brachial plexus | 1.5 | 3–7 | .... | 11.5 |
| Radial in arm | 3.0 | 5–7 | .... | 15.0 |
| Radial in forearm | 1.5 | 4–5 | .... | 10.5 |
| Ulnar in arm | 3.0 | 7 | 6 | 16.0 |
| Ulnar in forearm | 1.5 | 5 | 6 | 12.5 |
| Median in arm | 3.0 | 5–7 | .... | 15.0 |
| Median in forearm | 1.5 | 3–4 | 14.5 | 23.0 |
| Sciatic | 3.0 | 3–8 | .... | 14.0 |

The plexiform neuromata of von Recklinghausen's disease are so variable as to make it impossible to standardize the different therapeutic procedures. Occasionally, however, one is fortunate enough to encounter a localized form of the disturbance and the irregular, nodular enlargements of the superficial or subcutaneous nerves can be easily dissected out. As the twigs involved are often small or sensory ones, no nerve repair is usually required. If the overlying skin is pigmented or pedunculated, portions of it may be excised to gain a good cosmetic result, the cutaneous defect being closed by plastic procedures as the circumstances demand.

The neck is one of the most common sites for the nerve sheath tumors, particularly the benign perineurial fibroblastoma, which may arise from any one of the numerous sympathetic, cranial or somatic nerves which richly traverse this region (Figs. 9 and 10). One must be prepared to dissect deeply for these neoplasms which may be attached to the roots of the cervical plexus or extend to the very base of the skull if they arise from the vagus. When they originate from the cervical roots (most commonly the dorsal) dumb-bell shaped or hour-glass tumors[11] may lie partly in the spinal canal and also out in the soft tissues of the neck, hence the unwary operator may be led into a more extensive undertaking than had been anticipated. If the nerve trunk is divided in removing one of these cervical neoplasms, every effort should be made to resuture the cut ends, this consideration being most important in division of the hypoglossal nerve in order to prevent extensive atrophy of the tongue muscles.[7] On two occasions we have purposely divided the left vagus nerve without being able to repair it, and in neither case could we detect any disturbance in the cardiac or intestinal mechanisms post-operatively. In one of these cases a permanent hoarseness followed operation. On the whole, however, one commonly finds that it is possible to peel these cervical tumors away from the nerves which give rise to them and it is rarely necessary to completely divide one of these important trunks.

The thorax, while presenting relatively few of the nerve sheath tumors,

contributes an especially interesting chapter for the benignity of these neoplasms in the mediastinum or chest wall and makes their removal a most satisfactory undertaking. One of these cases in our series had a hen's egg size perineurial fibroblastoma of the superior mediastinum which was successfully removed by opening into the mediastinum through the sternum. The upper portion of the sternum was transected between the first and sec-

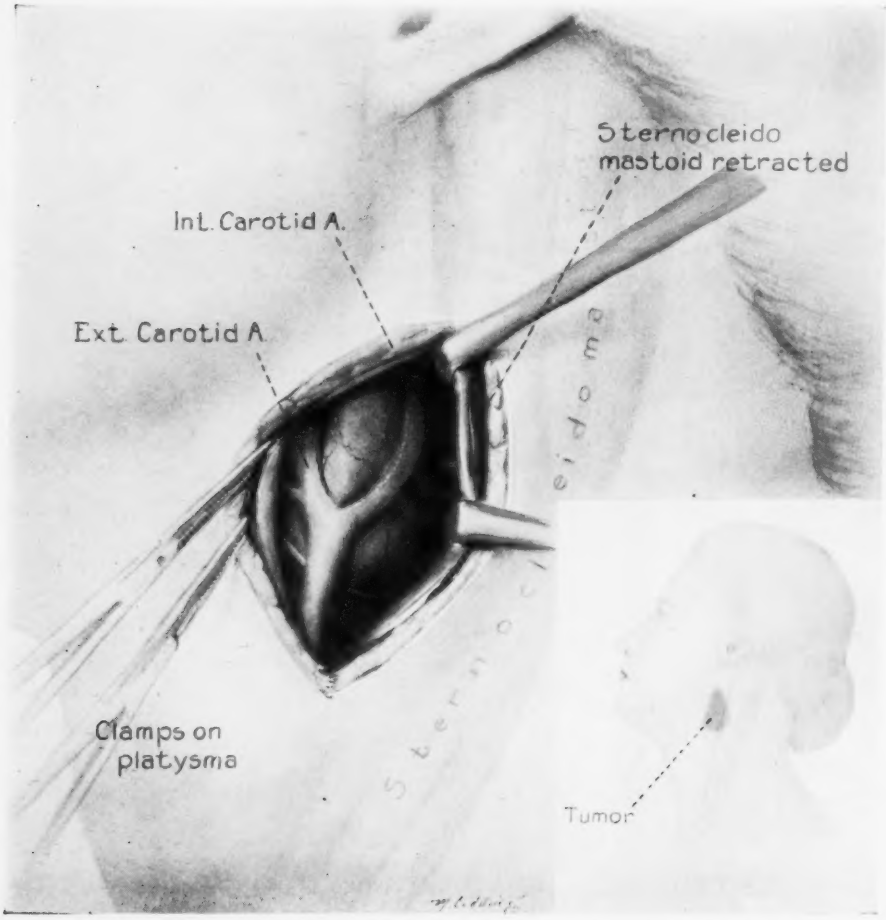


FIG. 9.—Operative exposure of a deeply attached cystic neurofibroma of the neck. A segment of the internal jugular vein has been resected to gain access to the neoplasm. The external carotid artery is compressed anteriorly and the internal carotid artery is pushed laterally. The mass was cleanly excised. Insert shows position of the tumor.

ond ribs and between the third and fourth ribs by the use of a Gigli saw. Cutting through the second and third costochondral junctions on either side then permitted the turning to the right of a skin, muscle, and bone flap, leading into the mediastinum as through a trap door (Fig. 11). Keller and Callender[14] removed a neurofibroma at the lower end of the left phrenic nerve, approaching it by an incision through the left fifth interspace, dividing and spreading the fifth and sixth ribs upward and downward respectively.

FIG. 10.—Photograph of neurofibroma of the neck showing extensive cystic degeneration. (From same patient as Fig. 9.)

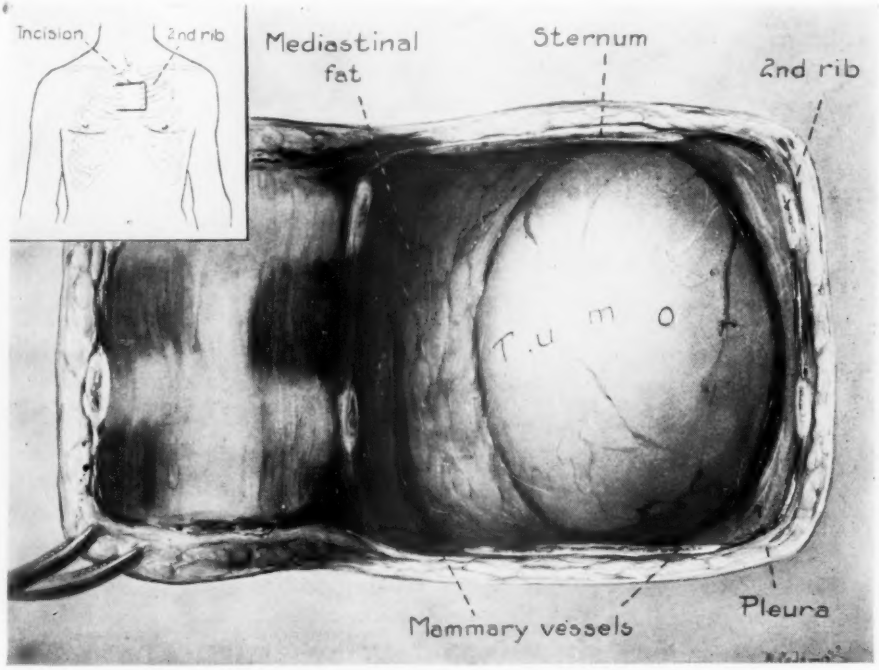


FIG. 11.—Sketch from successful removal of a mediastinal neurofibroma. Insert shows position of operative incision. A trapdoor, including skin, subcutaneous tissues and upper portion of sternum has been turned to the patient's right. The tumor was shelled out from its bed and dissected away from the parietal pleura on its left and the great vessels which lay deeply toward its right.

This gave good access to the region between the pericardium and the left parietal pleura.

In one of our patients with a large orange size perineurial fibroblastoma of the posterior portion of the right eighth intercostal nerve a successful and easy extirpation was completed by removing the posterior one-half of the ninth rib subperiosteally and then cutting across the eighth and tenth ribs posteriorly so that these latter could be spread apart. The pleural cavity was then entered by an incision through the bed of the ninth rib and the tumor, which projected into the thoracic cage, was easily excised from its attachments to the eighth intercostal nerve.

The posterior mediastinum is by far the best known site for the nerve tumors of the thorax. Since the spinal cord roots as well as the sympathetic nerves account for these posterior tumors, one finds that they lie close to the spinal column and extrapleurally. Thus they can usually be removed without entering the pleural cavity if a careful dissection is made. The operative approach then is usually by way of a paravertebral incision, cutting through the necks of two or more ribs to permit their separation. Again, one must be prepared to deal with an hour-glass tumor, opening the spinal canal at the same or subsequent sitting as the findings demand.

*Postoperative Care.*—Other than the usual care of the wound, little need be said concerning postoperative treatment excepting in those occasional cases in which a nerve trunk has been divided and resutured. When this latter has been done, the postoperative treatment should include an immobilization of the extremity, a graded return of motion of the part, and physiotherapy to those regions which are temporarily deprived of their nerve supply.

Immobilization is required to permit proper healing of the suture line and to give the best possible chance for the regenerating axis cylinders to grow down the distal part of the nerve trunk. It is especially necessary when a nerve gap has been overcome by flexing (or otherwise adjusting) the contiguous joints, because movement of these joints may tear apart the nerve repair. The duration of such immobilization must, of course, be decided for the individual case, but certainly it should never be less than three or four weeks and should better be maintained until there is evidence of return of nerve function. It is safer to err on the side of immobilizing too long rather than too short a period.

A graded return of motion should be ordered for the immobilized extremity. If a joint has been fixed in a given position to permit obliteration of a nerve gap, it is best to adopt some set schedule for reestablishment of the normal range of motion of this joint. Thus, if the elbow has been flexed at a 90° angle to permit suture of the median nerve in the antecubital fossa, it is best to maintain this right angle for a period of about one month and then to increase the extension at the elbow by two degrees daily, thereby passing a total of two and one-half months before getting the forearm straightened out to 180°.

Physiotherapy has a definite place in the postoperative regimen, for by

its judicial use the distal musculature and soft parts can be maintained in the best possible condition, and atrophy partially prevented while waiting for regeneration of the nerve. Baking and massage given daily or three times a week as the economic conditions warrant should be continued until restoration of active motion in all the paralyzed muscles heralds the return of nerve function. Physiotherapy can be administered while the limb is partially loosened but not removed from such immobilization apparatus as might be employed. Former teachings advocated the use of electrical stimulation of paralyzed muscles but experience has shown that this has little additional advantage and hence can be omitted with impunity.

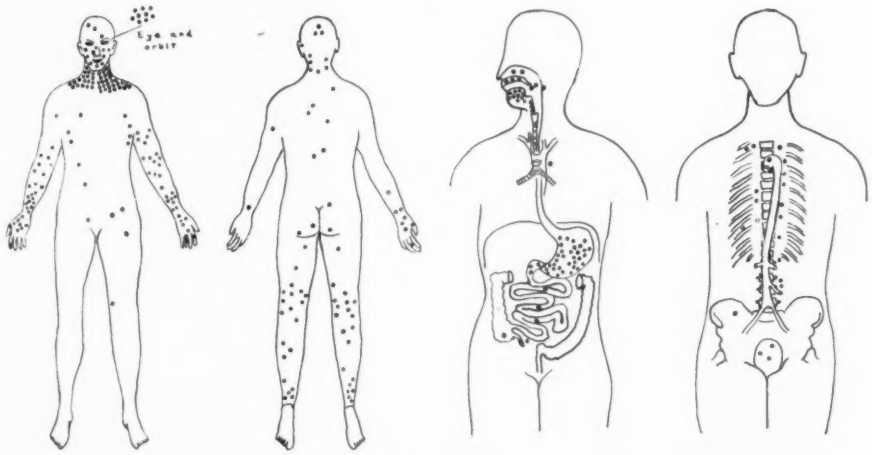

FIG. 12.—Distribution of benign perineurial fibroblastoma (from Stout, to which are added 17 cases of Mayo and Barber and 20 personally observed cases).

The length of time necessary for reestablishment of muscular and sensory function, naturally, depends on the length of the nerve trunk distal to the point of its severance and end-to-end suture. In general, under optimum conditions, the axis cylinders will regenerate at the rate of about 1 Mm. per day or roughly one inch per month. If there is no evidence of returning nerve function in twice the time calculated and allotted for its reestablishment, it is likely that the nerve suture has broken down and the ends separated or else a neuroma has formed at the site of operation and secondary suture in all probability will be required.

*Choice of Treatment in Various Types of Peripheral Nerve Tumors.*—The important tumors of the peripheral and sympathetic nervous systems may be classified as follows:

(1) von Recklinghausen's disease (neurofibroma).
(2) Perineurial fibroblastoma (neurilemmoma, schwammoma).
(3) Malignant perineurial fibroblastoma (malignant neurofibroma).
(4) Neurofibrosarcoma (neurogenic sarcoma).
    Arising in von Recklinghausen's disease.
    Arising in perineurial fibroblastoma.

(5) Cyst (?degenerated perineurial fibroblastoma).
(6) Neuro-epithelioma.
(7) Ganglioneuroma.

von Recklinghausen's disease in its generalized form usually does not call for operative treatment, but when it occurs as an isolated lesion or in the "forme frustes" the possibility of complete eradication makes surgical intervention advisable. Such plexiform neuromata can be dissected out with more or less ease, depending upon the extent and depth of the pathologic process. The generalized types of the disease may require surgery when large pedunculated masses cause discomfort and when undue rapidity of

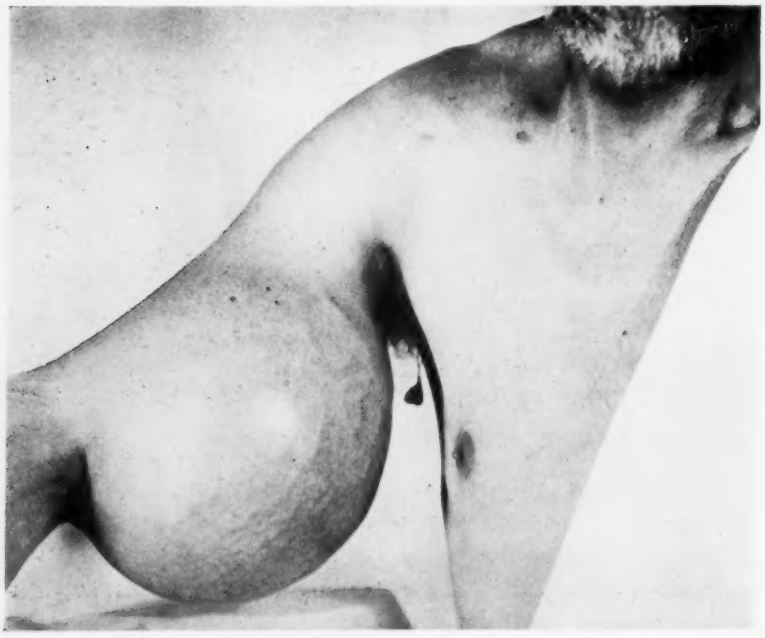

FIG. 13.—Neurofibrosarcoma of the median nerve in a 56 year old man. Small mass had been present for 20 years—followed by recent rapid growth and doubling of size in four months. Apparently malignant change in a previously existing neurofibroma. (No stigmata of von Recklinghausen's disease.)

growth suggests the possibility of malignant degeneration—a transformation which occurs in about 15 per cent of cases of von Recklinghausen's disease.

The perineurial fibroblastoma can practically always be treated by conservative surgery, for these lesions are slowly growing and if cleanly removed they rarely recur. When attached to small subcutaneous nerves, removal of a bit of the nerve causes little disability, but if the mass arises from a large nerve, it should be peeled away so as to leave the trunk intact. Figure 12 indicates the common positions of these growths, and as is seen, the most frequently involved sites are the neck, the front of the arms, and the backs of the legs.

The term malignant neurofibroma has been adopted by us to designate

several specimens which have shown a marked tendency to local recurrence and regional extensions. These uncommon growths do not exhibit a high degree of malignancy and do not metastasize by way of blood stream or lymphatics. They do, however, produce important local and regional invasions. While some authors have classified these neoplasms as slowly growing neurofibrosarcomata, we have preferred to employ a different term in speaking of them in order to point out their activity, which lies halfway between the neurofibroma or perineurial fibroblastoma on the one hand and the neurogenic sarcoma on the other. Their surgical treatment calls for a local but radical resection, and under no circumstances should attempts be made to separate them from the nerve trunk for this will almost certainly lead to recurrence and will doom to disaster a condition which previously had been

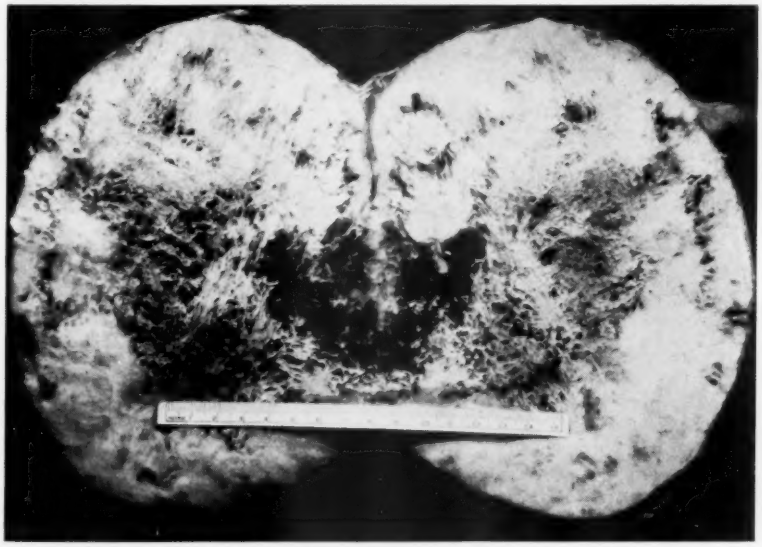

FIG. 14.—Rapidly growing neurofibrosarcoma of the median nerve. Specimen from case illustrated by Fig. 13.

curable. The excision, therefore, should always include a portion of the nerve trunk, which can be repaired at the same sitting by an end-to-end suture. We have justified this procedure in our own experience by removing such a neoplasm with a segment of the posterior cord of the brachial plexus. In spite of the postoperative total paralysis of radial and axillary nerves, the muscular and sensory functions of these nerves were completely restored in the arm within two years and there has been no evidence of recurrence of the neoplasm.

The neurofibrosarcomata, in the absence of demonstrable metastases, should be attacked radically from the outset. No form of local removal should be considered adequate if the growth appears on a limb, for early amputation may be a life-saving procedure. If pathologic examination of a specimen shows a sarcomatous growth in what was preoperatively thought to

be a benign lesion, amputation can be performed secondarily with some hope of cure. It must be noted, however, that one's suspicions concerning malignancy should be aroused before operation for there is almost invariably a history of rapid growth in a period of a few months or else there has been a sudden increase in size in a previously existing long standing benign tumor. If, therefore, a recent rapid growth has been noted, preparations should be made for competent pathologic examination at the time of operation, so that amputation can be done immediately if necessary. It is almost safe to say, however, that if there has been a recent marked increase in the size of the mass and if at operation there is no hemorrhage or cystic degeneration to account for this, the tumor may be considered almost certainly a malignant one. Figs. 13 and 14 are from a case of neurofibrosarcoma of the median nerve in a man 56 years of age. Fig. 15 shows the distribution of 137 malignant, nerve sheath tumors as compiled by Stout.

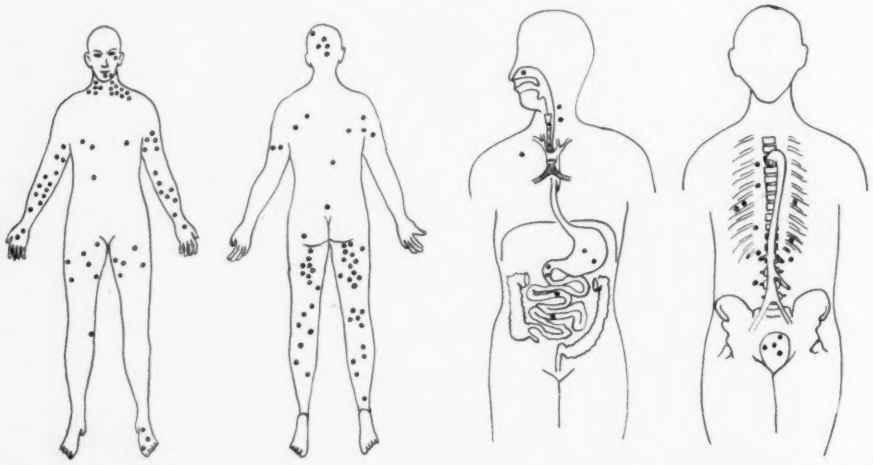

FIG. 15.—Distribution of 137 malignant nerve sheath tumors, occurring in 100 patients with von Recklinghausen's disease and in 29 patients without such stigmata (from Stout).

Cysts of the nerve trunk occur with rarity and their origin is not clearly understood. Since it is well known, however, that marked cystic degeneration often takes place in a perineurial fibroblastoma, it is only reasonable to believe that these nerve cysts, filled with watery or gelatinous fluid, take their origin from a previously existing nerve sheath tumor. The treatment, therefore, should be conservative, and consists of a simple dissection of the thin-walled sac away from the adjacent or surrounding nerve with as little interruption of the nerve fibers as is possible. The nerve can be split longitudinally so as to expose the cyst which lies within its substance, and by this technic the functional integrity of the nerve is not impaired.

Treatment of nerve cysts raises another possibility, namely, aspiration of the cyst or aspiration combined with injection of sclerosing fluids. Such therapy need only be rarely employed, but on one occasion we found it useful in treating a cystic, malignant neurofibroma of the face. In this patient a

large external mass in the region of the left zygomatic bone, extended internally to displace and involve the left side of the soft palate. Complete surgical removal was obviously impossible because of the anatomic location and only enough tissue for biopsy purposes was removed. Aspiration of the cyst, however, afforded considerable relief to the patient and the injection of fixative agents theoretically killed off a narrow rim of tumor remaining around the cyst wall.

The neuro-epitheliomata are lesions of an extraordinary high degree of malignancy and the same may be said regarding their treatment as was noted regarding the neurofibrosarcomata.

The ganglioneuromata are tumors of not too common occurrence, but their relative benignity and the fact that more than one-third of them are seen in childhood makes surgical removal a satisfactory and worthwhile procedure. McFarland and Sappington[19] collected 143 examples of this tumor from the literature. Among these cases the three most commonly involved sites were: retroperitoneal, 26; cervical, 17; thorax and mediastinum, 11. These neoplasms are well encapsulated, usually quite slowly growing and can be removed by local excision with a considerable degree of success and freedom from recurrence.

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# BENIGN METASTASIZING HEMANGIOMA

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A small group of hemangiomata is characterized by extensive metastases, in spite of the seemingly benign histologic structure of both the primary and secondary tumors. Only four apparently authentic cases of this condition have been reported: Borrmann,[1] 1906; Shennan,[2] 1914; Ewing,[3] 1919; Geschickter and Keasbey,[4] 1935. They have given rise to considerable discussion because the existence of such a group has an intimate bearing on the question of the essential similarity of benign and malignant processes and because they are difficult to classify. Some authors (Jaffe,[5] Wollstein,[6] Taylor and Moore,[7] and others) have even attempted to discredit altogether the criteria on the basis of which these tumors have been grouped together.

We have recently had the opportunity to study a case which helps to clarify the paradox of a metastasizing benign tumor.

## CASE REPORT

An 18 year old American girl entered the Tumor Clinic of the Massachusetts General Hospital complaining of a painless enlargement of the right breast of six months' duration. Three months after the lesion was first noted the breast became discolored and shortly afterward painful. Examination on admission showed that the right breast was about twice its normal size, forming a firm elastic mass with a purplish discoloration surrounding the nipple for about 8 cm. (Fig. 1). There was no increase in local temperature, no pulsation in the mass, and no discharge from the nipple. A small pigmented nevus was present on the opposite breast, but no other skin tumors were seen.

A preoperative diagnosis of hemangioma was made and a simple mastectomy performed.

Gross examination showed a right breast measuring 14.5 x 11.5 x 8.5 cm. covered by an elliptical piece of skin 14.5 x 8.5 cm. The nipple was negative. Just to one side of the nipple there was a mottled purplish discoloration of the skin over an area 5 x 3 cm. in size. Nearly all the breast tissue was replaced by a large, fairly well encapsulated, rather soft, mottled, purplish-gray tumor 10.5 cm. in diameter and 3 cm. in thickness. The capsule was quite adherent around the periphery and in places could not definitely be made out. The cut surface was edematous, light gray in color, and honeycombed with small cystic spaces filled with blood.

Microscopic examination showed a lesion consisting of small and large cystic spaces filled with blood and lined by small, uniform, apparently quite well differentiated endothelial cells. No mitotic figures were seen (Fig. 2). The lesion extended widely throughout the breast tissue, showed slight invasive properties, but no histologic evidence of rapid growth. Because of this tendency to infiltrate the breast tissue and in spite of the fact that its structure was that of simple angioma, the tumor was not considered entirely benign.

Eight months after the mastectomy the patient returned to the hospital. A keloid had developed in the scar and two small hemangiomata had now appeared, one over the right lower ribs posteriorly and the other in the right supraclavicular region. During

the following month two more lesions appeared, one on the chest, 1.5 x 1.3 cm. in extent, and the other on the scalp, 5 x 3 cm.

At this time roentgen therapy was started. During the next four months all the lesions except that in the scalp received three to four doses of .8 skin units* superficial therapy at monthly intervals. At the end of this period the treated lesions showed considerable flattening without, however, any definite decrease in width. The scalp lesion was then treated with monthly doses of .8 skin units for three months. Two new lesions appeared on the abdomen, followed rapidly by numerous others over the abdomen and back. An attempt to treat all of these was quite impractical. The scalp tumor began to grow rather rapidly, reaching three times its original size. It was then excised—one year after it was first noted, 20 months after the original mastectomy.

The pathologic diagnosis was hemangiosarcoma. This metastasis was quite different from the original tumor. The cystic angiomatous spaces had disappeared. The cells were quite spindle shaped, small, contained hyperchromatic nuclei, and were definitely

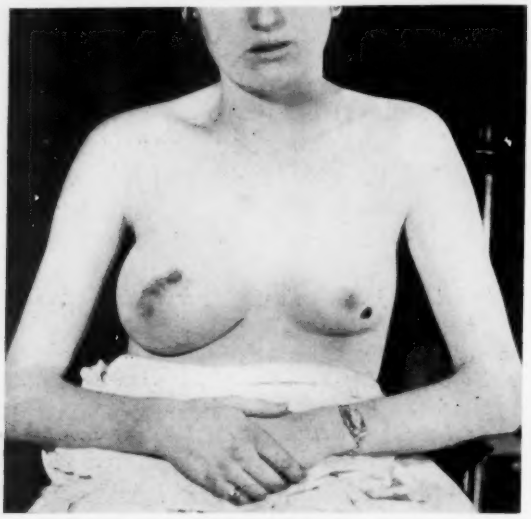

FIG. 1.—Showing the enlargement of the right breast, when first examined.

angioblastic. Mitotic figures were present and there was definite evidence of infiltration (Fig. 3).

Since there did not appear to be any involvement of the internal organs, an attempt was made to determine the radiosensitivity of some of the individual skin lesions. Two groups were selected: (1) the older lesions previously treated with superficial roentgen ray and (2) a few of the recent untreated masses. Each lesion received during a two week period 1,600 r (two erythema doses) of medium wave roentgen ray in one dose. A few received 3,200 r in two doses. Two months later the skin over the treated areas was flat and scaly; no masses could be felt. The untreated lesions, however, had grown slowly although no new tumors appeared. An hemangioma in the left breast

*A skin unit refers to a threshold erythema dose (350 r) of superficial or long wave roentgen ray delivered at 100 kilovolts, 5 milliamperes, 8 inch distance, .5 aluminum filter. "Medium wave therapy" refers to roentgen rays delivered at 140 kilovolts, 5 milliamperes, 4 Mm. aluminum filter, 50 inches. "Deep therapy" refers to short wave roentgen rays delivered at 200 kilovolts, 50 cm., 5 milliamperes, .5 Mm. copper filter. In the case of medium and deep roentgen ray therapy, 800 r measured in air is considered the equivalent of an erythema dose.

which was treated with 900 r right side and 900 r left side deep therapy through a 10 x 10 field, in divided doses of 300 r each, showed slight softening. The lesions were so numerous, however, that they could be counted only with difficulty. Many were barely perceptible and others appeared to be mere discolorations or spongy elevations. The attempt to treat them individually was therefore abandoned.

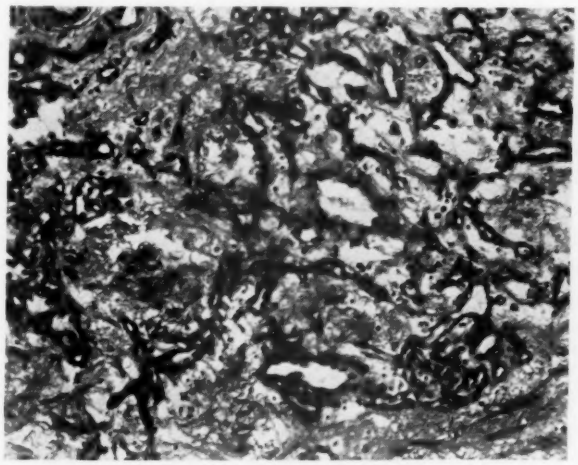

FIG. 2.—Photomicrograph of the primary tumor of the right breast, showing a fairly characteristic hemangioma.

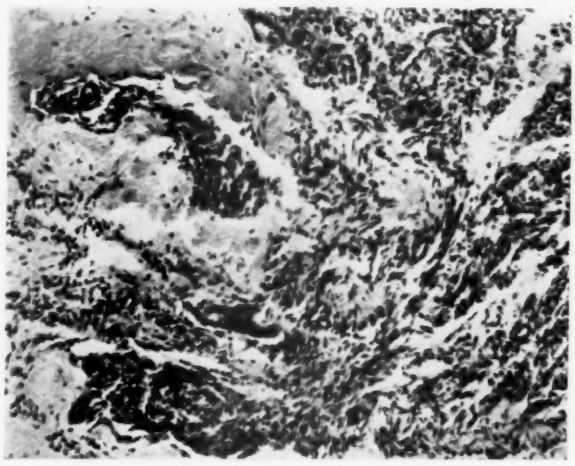

FIG. 3.—Photomicrograph of the metastatic nodule in the scalp, showing definite sarcomatous changes.

The patient left the hospital and did not return for five months. At this time the left breast was tremendously enlarged, discolored, and tense (Fig. 4). A palliative partial mastectomy was done. A large part of the tumor had invaded the chest wall and mediastinum. The histologic structure was similar to that observed in the scalp tumor; mitotic figures were fairly numerous. The patient was discharged and three months later died at home, three years after the first breast tumor was noted. An autopsy was not performed.

Borrmann,[1] in 1906, reported the first case of this previously unrecognized

form of angioma, that of a female, aged 26, who had developed a walnut sized tumor in the right breast. It was excised a few months later but recurred five times during the following year, each recurrence being excised in turn. In addition a mass appeared in the scapular region which was also removed. The patient died 21 months after the tumor was first noticed, 17 months after excision. Autopsy showed another recurrence in the region of the primary site and a similar mass in the left buttock. Both lungs were filled with small hemangiomatous masses and the pleural cavities contained bloody fluid. The original tumor was not available for study, but all the recurrences and the metastases showed a structure fairly characteristic of

FIG. 4.—Appearance of patient two years and three months after her first admission, showing the numerous metastases in the skin and the marked involvement of the left breast.

telangiectasis or simple angioma. Borrmann emphasized the fact that there was nothing to distinguish any of them from benign hemangiomata without metastases.

The second case, reported by Shennan,[2] in 1914, was that of a female, aged 23, with a six year history, beginning with hemoptysis and later followed by splenomegaly, hemothorax and ascites. During her illness three small tumors appeared on the skin, one of which was excised and proved to be a cavernous hemangioma. At autopsy tumors of similar histologic structure were found in the spleen, lungs, thymus, bone marrow, liver and lymph nodes. The primary source was evidently in the mediastinum. In none of the organs did the histology remotely suggest sarcomatous change. While it cannot be denied that the internal tumors might possibly have been

slowly growing multiple benign angiomata, the skin lesions were presumably metastatic, and it is probable from the history that the larger tumors were, also.

Ewing[3] discusses the case of a middle aged woman with a bulky cavernous hemangioma of the breast with numerous metastases to the skin and lungs. The structure was similar to that described by Borrmann.

Geschickter and Keasbey[4] mention the case of a 62 year old man with angiomatous masses in both iliac fossae, lungs, pleura and spleen, all of which showed the histologic structure of an apparently benign angioma.

Discussion.—Although varying in structure—Borrmann's case was a simple angioma; Ewing's was "quite similar"; Shennan's was a cavernous hemangioma; Geschickter and Keasbey's consisted of tightly packed spindle cells surrounding sinuses lined by endothelium—these four cases conform to the definition of this group: that is, they are metastasizing angiomata in which both the primary and secondary tumors are seemingly histologically benign. For this reason, they should be separated from two other large groups of hemangiomata. The first of these are the definitely malignant metastasizing hemangiosarcomata—*e.g.*, the cases reported by Pick, Stamm, Ullman, Kopf, Theile, and Jores (mentioned by Sonntag[8]), the cases of Wright,[9] Hall,[10] and others. The second are the multiple (not metastatic) benign hemagiomata, particularly those occurring in children, which by local invasive growth, location or hemorrhage may cause death, among them the cases reported by Homans,[11] Jaffé,[5] Wollstein,[6] Taylor and Moore,[7] and many others.

Borrmann discussed his case under the title of "Metastasenbildung bei histologisch gutartigen Geschwülsten" in order to clearly emphasize the vagueness of the boundary between benign and malignant tumors. He felt that the presence of metastases could no more be used to determine definitely the benign or malignant character of a process than, for example, the absence of a capsule, invasiveness, or rapid growth: these, we know, are not exclusively benign or malignant properties. Shennan, on the other hand, although agreeing with Borrmann with reference to the classification of these angiomata, calls attention to another problem which we consider more important; *viz.*, whether the histologic criteria, rather than the clinical, are not at fault.

Ewing feels that this group of angiomata is a borderline entity, "cavernous or more cellular angiomas possessing certain peculiar features of malignancy." Livingston and Klemperer[12] describe the histology of a single hemangioma invading the scalp. They considered the stroma, which simulated that of Borrmann's case, to be undifferentiated mesenchyme rather than simple connective tissue. They believed that the tumor reported by them and those reported by Borrmann, Shennan and Ewing possess similarities which justify their inclusion in a group by themselves—as malignant mesenchymal angiomata. Since the outstanding clinical feature of Livingston and Klemperer's case was the local invasive growth, their hypothesis, if true, might well explain the invasive properties not infrequently seen in solitary

angiomata. Their case, however, does not show the essential feature characterizing the other three: namely, the production of metastases. We are not certain, therefore, that the conclusions they have drawn from their case can be applied to these others.

Wright[9] divided metastatic hemangiomata into two general groups. He differentiates those with a histologically benign structure (cases of Shennan, Borrmann, and Ewing) from those with a histologically malignant structure (cases of Theile, Jones, Langlans, and his own, all of which were hemangiosarcomata of the spleen with metastases to the liver and other organs). He points out that the common feature of both groups was the formation of metastases, the histologic structure of which was similar to that of the primary tumor. In none did the primary benign hemangioma give rise to metastases with structural characteristics of malignancy.

It seems to us that the case we are reporting is a connecting link between the four cases cited in the literature and the true angiosarcomata. Ours is evidently an example of an apparently histologically benign tumor giving rise to malignant metastases. To assume that this is a case of multiple tumors one would have to admit that there were numerous hemangiomatous rests, such as Ribbert (quoted by Borrmann) describes, which began to grow under the influence of local or general factors. If this were true one would expect these secondary tumors to have been discernible either at the same time as the original tumor or certainly within a shorter period than one year. Since it is highly improbable that this is a case of multiple tumors, but rather that the lesions that appeared following the original breast tumor were really metastases, we must conclude that we are dealing with a process which was malignant from the onset and that the primary tumor, in spite of the absence of histologically malignant properties, was not benign. We feel that because the histologic structure of our case is very similar to the quoted cases, especially those of Borrmann and Ewing, it is probable that the latter were also primary malignant tumors. This is in agreement with Shennan's concept that it is the occurrence of metastasis which should be the deciding factor and not the histologic features.

In addition to its bearing on the classification of these angiomata, our case is also of interest because an opportunity was afforded to study the response of these tumors to various forms of treatment—surgical excision, suberythema doses of superficial roentgen rays, divided dose deep therapy, massive dose of intermediate therapy, and various combinations of these. In using suberythema doses of long wave length roentgen ray our aim was the production of an obliterating endarteritis in the tumor, comparable to the commonly accepted method of treating hemangiomata of the skin with small doses of radium at long intervals (Roesler,[13] Kaplan,[14] Baensch[15]). In using the deep and intermediate therapy an attempt was made to actually destroy the lesion. The response of the tumor, in spite of the large doses used for some of the lesions, was only temporary. There is very little doubt, therefore, that these tumors are highly resistant to radiation.

Before leaving the subject of radiation the remote possibility of the roentgen ray itself producing sarcomatous changes in the treated tumors should be mentioned. Sarcomatous degeneration as the result of radiation is extremely rare, and a *post hoc ergo propter hoc* element in the few reported cases cannot be excluded (Livingston and Klemperer). No case of such degeneration has ever been reported in a benign hemangioma treated by roentgen ray or radium, although radiation treatment of these is quite common. Other factors, such as the small amount of radiation which the masses in the scalp and left breast (both hemangiosarcoma) received, further reduce this remote possibility.

SUMMARY.—(1) So called "benign metastasizing hemangiomata" are defined and their classification and significance are discussed.

(2) An unusual case of an angioma of the breast with benign histologic characteristics which produced definitely malignant metastases is reported. Because of the histologic similarity of the primary tumor in this case to reported cases of so called "metastasizing benign angioma" the benign character of the latter must be questioned.

(3) The response of this tumor to various forms of radiation shows it to be highly radioresistant.

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# THE IMPORTANCE IN SURGERY OF THE BLOOD CIRCULATION TIME

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IN HIS work, the surgeon is confronted with two problems. First, he has to select the type of procedure best suited to the disease from which the patient is suffering, and secondly, he has to evaluate the risk of the procedure on the individual patient. In other words, to estimate as exactly as possible all the factors entering into the conception, "surgical risk." Of these factors, the function of the heart and kidneys is of paramount importance. In the presence of pronounced lesions of these organs, the estimation of their function is comparatively easy and the surgeon is guided by the clinical examination and routine laboratory tests. A large number of patients, however, are on the borderline of the class considered "poor surgical risks." In these, neither examination of the heart nor routine urine and blood examinations will disclose the impending danger of latent cardiovascular insufficiency. These cases are responsible for a large percentage of the mortalities, both in elective and emergency surgery.

Any method permitting a better evaluation of this latent cardiovascular disability should be a welcome addition to our diagnostic and prognostic armamentarium. Prerequisites for any additional method used for this purpose must be reliability and simplicity. The quest for such additional methods led us to the use of blood circulation time estimations.

Having passed through an evolutionary process of its own, the estimation of the velocity of blood circulation is now recognized as an accurate and useful diagnostic measure by many research workers and clinicians.[1, 2, 3, 4, 5]

The technic of the procedure has been simplified to a great extent, and as used by us the test can be applied to great advantage by any one proficient in intravenous medication. It occupies less time than a routine blood count and employs no other instrumentation than an hypodermic syringe and several solutions as mentioned under TECHNIC.

We have conducted the present study on circulation time with the following desiderata in mind.

(1) As a means of studying the effects of spinal anesthesia, morphine administration, and abdominal distention, on the velocity of blood flow through the lungs and their possible relationship to postoperative pulmonary complications.

(2) As an aid in cases where a differential diagnosis between cardiac or infradiaphragmatic disease must be established.

(3) As an aid in evaluation of the patient as a surgical risk.

(4) For the purpose of studying the change in circulation time in definitely established pulmonary affections and the relationship of these changes to the pulmonary complications.

TECHNIC.—Essentially, the technic as described by Fishberg, Hitzig and King[4] was followed throughout in this study. The antecubital vein was punctured by a No. 19 gauge needle, to which a three way adapter and syringe are attached. To the side outlet of the adapter, a graduated pipette is attached, into which the blood is allowed to flow to establish the venous pressure (Taylor, Thomas and Schleiter[6]). To assure accurate readings of the venous pressure values, the elbow must be supported at a level so that the vein is 5 cm. below the anterior surface of the sternum at the fourth rib. The pipette is rinsed with sodium citrate solution to prevent clotting of the blood. Following this estimation and without removal of the needle, a solution of 2½ Gm. of soluble saccharin dissolved in 2.2 cc. of distilled water (this solution is freshly prepared in a test tube and sterilized over an alcohol flame) is injected into the vein. The time elapsing from the moment of the injection up to the time the patient experienced a sensation of sweetness on his tongue is measured by a stop watch and recorded as arm-to-tongue or saccharin time. This represents the time it takes a particle of blood to pass from the vein injected to the capillaries of the tongue. It is the sum total of vein-to-heart time, the intracardiac time, the intrapumonary time and the heart-to-tongue capillary time. A second syringe containing 5 minims of ether and 5 minims of saline is then applied to the adapter and the contents injected into the same vein. The breath of the patient is smelled by the observer, and the time recorded when ether is first noticed in the exhaled air. This is known as "ether time" and represents the vein-to-heart plus right heart-to-lung time.

The tests were all conducted at resting conditions and checked by two observers. The saccharin test, though subjective in nature, is so very definite that even the most unintelligent patient cooperates satisfactorily. Repeated readings in 23 normal individuals showed a maximum variation in saccharin time of 3.5 seconds and an average variation of 1.4 seconds. The maximum variation in the ether time was six seconds and the average variation of 1.5 seconds.

Normals established in 70 readings on 42 surgical patients admitted to the wards of the Coney Island Hospital for various conditions such as appendicitis, gallbladder disease, fractures, *etc.*, and whose ages varied from adolescence to advanced middle age, gave 10.7 seconds as the average normal saccharin time and 6.3 seconds as the average normal ether time.

The variations in this group were as shown in the table on p. 462.

Blumgart and Weiss,[7] measuring the velocity of blood flow in normal individuals, showed that the maximum variation in repeated circulation time measurements on the same individual did not exceed three seconds. It has been further established that there is no critical age beyond which the

| Saccharin Time | | | Ether Time | | |
|---|---|---|---|---|---|
| Seconds | | No. of Readings | Seconds | | No. of Readings |
| 6 | | 2 | 2 | | 1 |
| 7 | | 3 | 3 | | 3 |
| 8 | | 10 | 4 | | 6 |
| 9 | | 10 | 5 | | 12 |
| 10 | | 14 | 6 | | 12 |
| 11 | | 9 | 7 | | 26 |
| 12 | | 4 | 8 | | 3 |
| 13 | | 8 | 9 | | 3 |
| 14 | | 4 | 10 | | 3 |
| 15 | | 2 | 11 | | 1 |
| 16 | | 1 | 12 | | 0 |
| 17 | | 2 | 13 | | 0 |
| 18 | | 1 | 14 | | 0 |
| 10.7 | Average | 70 | 6.3 | Average | 70 |

velocity of blood flow changes, and that the elevation of arterial blood pressure does not influence the circulation time of the blood.

*Increase of Speed.*—Increase of speed of blood flow occurs in:

(1) Exercise.—From 50 to 100 per cent. Hence all tests must be made under conditions of physical rest.[8]

(2) Thyrotoxicosis.—The speed being roughly proportional to the increased metabolic requirements.[9]

(3) Marked Anemia.—Primary and secondary, roughly in proportion to the degree of the anemia.[10]

*Decrease in Speed.*—Decrease in the velocity of blood circulation, or conversely, increase in circulation time occurs in:

(1) Myxedema.[11]

(2) Polycythemia.[10]

(3) Various types of heart disease. When present it reflects the disfunction due to myocardial involvement. This is true of any kind of heart disease, be it rheumatic, luetic, arteriosclerotic or hypertensive. Prolongation of the circulation time is due commonly to the insufficiency of the left heart with pulmonary engorgement. This retardation of the velocity of the blood circulation as measured by the "Saccharin Test" may occur in cardiac patients *before* other symptoms are manifest or subjective disturbances noticed.[13] In such cases, the measurement of the circulation time is the only means of discovering the cardiac lesion. In a few exceptional cases of pronounced heart failure, normal figures for circulation time have been obtained.[13]

(4) Local obstructive factors in the circulatory pathway, such as mediastinal or cervical tumors, aortic aneurysms, *etc.*, must be eliminated in evaluating increased circulation time readings.

*Circulation Time as Effected by Operation.*—Forty-two patients, of whom all but three were subjected to major surgical procedures, as indicated in

Table I, were fair operative risks as judged by the usual clinical and laboratory procedures.

TABLE I

| OPERATIONS | No. |
|---|---|
| Appendectomy | 14 |
| Hysterectomy | 6 |
| Cholecystectomy | 8 |
| Hernioplasty | 5 |
| Thyroidectomy | 1 |
| Cholecystectomy-hysterectomy | 1 |
| Anterior-posterior colporrhapy | 1 |

The age distribution was as follows: 15 to 30 (17); 30 to 40 (6); 40 to 50 (17); 50 to 60 (2). All the operations were performed under spinal anesthesia. There was uniformly a mild temperature reaction on the first day. This was associated with some acceleration of the pulse rate. All patients were adequately morphinized, so there was a minimum of postoperative discomfort. In a moderate number of instances there was mild abdominal distention on the first postoperative day. Snug, and in some cases tight, abdominal dressings were applied in all cases unless there was some definite contra-indication. Repeated postoperative C. T. readings were made in 23 instances, (24 to 36 hours postoperatively) and in 12 cases only a single reading (12 to 24 hours postoperatively) was made. Of the 12 single postoperative readings made, all were within normal limits. In the 23 cases in which pre- and postoperative readings were made, no significant variations could be demonstrated. The maximum variation in S. T. was 3.5 seconds. The average 1.5 seconds. The maximum ether time variation was six seconds (one case). The following inferences can be drawn from the study:

(1) Repeated C. T. readings in an individual in whom there is no intrathoracic disease or local obstructive factor, are relatively constant or show only minimum variation.

(2) Laparotomy. Upper or lower has no effect on C. T.

(3) Morphine in clinically effective doses has no effect on C. T.

(4) Slight elevation of pulse rate and temperature. Such as are encountered postoperatively, have no effect on C. T.

(5) Moderate abdominal distention or tight abdominal dressings have no effect on the C. T.

(6) Age, *per se*, has no effect on C. T.

*Circulation Time in Spinal Anesthesia.*—Six cases are presented (Table II) where the C. T. was recorded before and within half an hour after the administration of spinal anesthesia. Preoperative blood pressure was normal in this group. As a result of the anesthesia, there was a fall in blood pressure from an average of 113/88 prespinal to 92/58 postspinal. The average pulse rate changed from 88 to 90. Conclusions: No significant variation in the C. T. occurred as a result of the spinal anesthesia. These findings are of interest particularly in view of the postspinal fall in blood pressure and

changes in pulse rate. Further observations which will permit more accurate deductions on this all important phase are being conducted.

TABLE II

DIRECT EFFECT OF SPINAL ANESTHESIA

| Case No. | Age | Operation | Prespinal Readings | | | | Postspinal Readings (within ½ hr.) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pulse Rate | Blood Press. | S.T. | E.T. | Pulse Rate | Blood Press. | S.T. | E.T. |
| 1 | 20 | Appendectomy | 90 | 128/80 | 10. | 7. | 110. | 98/50 | 8. | 4. |
| 2 | 34 | Hysterectomy | 80 | 136/90 | 10. | 6. | 100. | 82/60 | 8. | 6. |
| 3 | 35 | Cystocele operation | 80 | 114/82 | 12. | 8. | 90. | 114/82 | 11. | 7. |
| 4 | 32 | Bilateral herniorrhaphy | 90 | 148/110 | 13. | 7. | 74. | 70/52 | 15. | 8. |
| 5 | 32 | Cystocele and rectocele op. | 80 | 130/80 | 12. | 9. | 90. | 90/60 | 11. | 9. |
| 6 | 24 | Exploratory laparotomy | 110 | 130/90 | 18. | 8. | 80. | 94/52 | 9. | 7. |

*Circulation Time and Differential Diagnosis.*—In the six cases analyzed in Table III, the C. T. was well above normal. In five of the cases, the diagnosis of peptic ulcer was made on admission to the hospital. Further investigation revealed the presence of arteriosclerotic heart disease, in two cases (1 and 4) and completely negative findings in the gastro-intestinal tract.

Cases 2 and 3 had acute coronary arterial disease (confirmed by autopsy) with coincident perforation of gastric ulcers. Case 3 was operated upon for the gastric lesion. Death occurred one hour after operation. Autopsy revealed a fresh myocardial infarct.

Case 5 died 36 hours after admission. No operation. Roentgenogram showed an enlarged heart. Electrocardiogram showed left ventricular hypertrophy with premature contractions. The abdominal signs cleared up after 12 hours' observation. The cardiologist (Doctor Sigler) was of the opinion that the heart was responsible for the symptoms and the sudden death. An autopsy was not obtained.

Case 6 had complaints typical of gallbladder disease of several months' duration. The gallbladder series was negative. The gastro-intestinal tract was negative except for marked periduodenal adhesions. The patient appeared to be in excellent physical condition. Exploratory laparotomy and cholecystectomy were performed under spinal anesthesia. Towards the end of the operation (one-half hour) the heart suddenly stopped beating. With continued respiration, the patient was revived by stimulation, death ensuing several hours later. Critical analysis of the case made us believe that death was caused by a cardiac accident, probably coronary occlusion. Autopsy was not obtained.

In each of these six cases, the prolonged C. T. proved to be of great significance from the diagnostic standpoint. All of the patients were acutely sick on admission; histories and physical findings suggested upper abdominal catastrophes. Immediate consultations with a cardiologist, and electrocardiographic studies permitting a complete investigation of the heart, would have

TABLE III

CIRCULATION TIME AS A DIAGNOSTIC MEASURE

| Case No. | Age | Symptoms | V.P. | S.T. | E.T. | Pulse Rate | Blood Pressure | Roentgen ray | Heart | Admission Diagnosis | Final Diagnosis | Clinical Course |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 42 | Severe epig. pain and G-I complaint | 6 | 21 | 10 | 80 | 110/80 | Chest and G-I neg.; Wass. 4+ | P. X. neg. | Penetrat. ulcer | Coronary disease | Developed typical coronary disease |
| 2 | 40 | Collapse; rigid abdomen | 0 | 31 | 11 | 120 | 70/50 | None | Severe shock; tones indistinct | Ruptured ulcer | Rupt. G. ulcer; coronary occlusion | Died, autopsy: perforated ulcer and coronary occlusion |
| 3 | 45 | Rigid upper abdomen; pain 5 days' duration | 6 | 23.5 | 9 | .. | ..... | None | Size normal; no murmur; tones muffled | Perforat. ulcer | Perforat. ulcer; coronary occlusion | Death 1 hr. p.o. rupt. duoden. ulcer, coronary occlusion |
| 4 | 68 | Upper abdominal pain; perforated viscus? | .7 | 22 | 11 | 120 | 96/79 | None | P. X. neg. | Perforat. ulcer | Myocardial disease | Abdominal symptoms subsided; improvement under cardiac regimen |
| 5 | 54 | Upper abdomen tender with spasm; rupt. ulcer? | 15.5 | 27 | 17.5 | 80 | 116/84 | Flat film no free air | Ecg.-L. ventr. premature contr. | Perforat. ulcer | Luetic myocarditis; aneur. aorta | Died 36 hrs. later; no evidence of intra-abdominal disease |
| 6 | 50 | Right upper abdominal pain; acute G-B? | 12 | 21 | 9 | 76 | 92/70 | G-B. series neg., periduodenal adhes. | Normal findings | G-B. disease | Cardiac failure | Cholecystect.; G-B. no pathology; heart stopped beating on table. With cont'd respiration resuscitated. Death 6 hrs. later |

Volume 104
Number 3

delayed surgical therapy that seemed imperative at the time of admission for several hours. Examination of the C. T., however, gave us a very definite idea as to the presence of myocardial dysfunction, regardless as to whether or not coincident intra-abdominal disease was present.

*Significance of Postoperative Changes of Circulation Time.*—In the cases outlined in Table IV, an interesting feature may be observed. Preoperatively, the C. T. was normal in most of the cases (except Case A). Yet, postoperatively, a definite rise in C. T. was observed. All of these cases developed pulmonary complications.

**Case 1.**—A female of 57. Radical mastectomy for carcinoma of the breast. Preoperative roentgenogram of chest, negative. S. T. 8, 24 hours later S. T. was 20. Four days later, fluid appeared in left chest. One month later, chest clear; S. T. 14.

**Cases 2 and 7.**—These are of particular interest. Preoperative C. T. normal. On the first postoperative day, both showed marked slowing of C. T. Neither had clinical signs of pulmonary complications. Roentgenograms at this time revealed areas of infiltration and congestion. Both made uneventful recoveries with the return of C. T. figures to normal.

**Cases 3, 4, 5, 6 and 8.**—All had definite postoperative pulmonary complications, diagnosed clinically and roentgenologically. The preoperative C. T. was normal in all of them. A definite and marked increase in the C. T. was observed with the onset and during the course of the pulmonary symptoms, in Cases 4 and 6, both of which had pulmonary atelectasis. The C. T. returned to normal following resolution of the pulmonary process.

In Case 8, there was no increase of the C. T., notwithstanding the presence of extensive pulmonary involvement. This, however, may be explained by the fact that the patient was in an oxygen tent most of the time receiving a ten per cent mixture of oxygen and carbon dioxide. He developed a most intensive hyperpnea (resp. 40 to 50) a condition which, normally, will increase the speed of circulation.

It is of interest to note in this connection that pulmonary atelectasis is practically unknown following operations for toxic goiter, also that the velocity of blood flow is greatest in this disease. Contrasting these two facts, it seems probable that a definite relationship exists between the slowing of the C. T. and the development of pulmonary atelectasis.

We would like to comment on several other interesting findings:

**Case A.**—A man of 42 sustained a chest trauma, which caused a fracture of several ribs. Pleural effusion with fever and cough developed. The C. T. at this time was S. T. 20; E. T., 12. Six days later, when the symptoms subsided, and the temperature was normal, the S. T. was 14 and the E. T. 8.

**Case B.**—Man, aged 40, with a postpneumonia empyema. S. T. 18; E. T. 10. After drainage of the empyema, S. T. 17; and E. T. 8.5. This lack of improvement in the C. T. prompted us to have an electrocardiogram made. This showed definite myocardial damage, which may well have been the cause of the constantly high S. T.

**Case C.**—An obese female of 34, with a blood pressure of 128/78, had an S. T. of 30, and E. T. 12, venous pressure 8. Because of this finding, roentgenograms of the chest were taken. They revealed bilateral chronic bronchitis and bilateral upper lobe fibrosis.

## TABLE IV

### RELATION OF CIRCULATION TIME READINGS TO PULMONARY COMPLICATIONS

| Case | Age | Diagnosis | Preoperative | | | Postoperative Readings | | | | | | | | | | | Roentgenologic Findings | Temp. | Pulse | Blood Pressure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | V.P. | S.T. | E.T. | | V.P. | S.T. | E.T. | | V.P. | S.T. | E.T. | | V.P. | S.T. | E.T. | | | | |
| 1 | 57 | Ca breast | 7 | 8 | 4 | 24 hrs. | | 20 | 7 | 1 mo. | 10 | 14 | 14 | | | | | 8/30 Fluid in chest<br>9/6 Left pleura—fluid | | | 150/90 |
| 2 | 48 | L. ing. hernia | 7 | 14 | 7 | 8/17 | 8.5 | 25 | 12 | 8/20 | 10 | 13 | 8 | | | | | Areas of pneumonic infiltration; no clinical signs | 96° | 100 | |
| 3 | 42 | Appendicitis | 8 | 8 | 5 | 48 hrs. | | 21 | 8.5 | 5 days | 8 | 19 | 8.5 | | | | | Bronchial pneumonia at base of right upper lobe | 102° | 100 | 145/90 |
| 4 | 21 | Hernia | | | | 7/21 | 5 | 22 | 10 | 7/25 | 14 | 20 | 8 | 7/31 | 7 | 10 | 5 | Right lobe atelectasis | 102° | 99 | 120/80 |
| 5 | 36 | Acute append., chr. bronchit. | | | | 7/26 | 10 | 10 | 5 | 7/28 | 12.5 | 15 | 9 | | | | | Bronchial pneumonia — lower left lobe | 103° | 100 | |
| 6 | 20 | Atelectasis of lung | | | | 3 days | | 23 | 7 | | | | | | | | | | | | |
| 7 | 43 | Cardiospasm | 4 | 10 | 4 | 8/1 | 16.5 | 24.5 | 7.5 | 8/3 | 3.5 | 10 | 4.5 | | | | | Cardiospasm; bilateral pulm. congestion and some bronchial changes | 102° | 120 | 122/80 |
| 8 | 45 | Strangulated hernia | | | | | | 12 | 9 | | | | | | | | | 10/24 chest neg. 10/29 Dyspnea and cough. Bilateral pneumonia congestion and bronchitis. Pneu. infiltra. both lower lobes and r. upper lung, mid portion | 101° | 90 | |
| A | 42 | Multiple rib fractures | (After accident) | | | | 9 | 20 | 12 | 6 days | 6 | 14 | 8 | | | | | Evidence of pleural effusion | | | 140/80 |
| B | 40 | Empyema | 12 | 18 | 10 | | 11 | 17 | 8.5 | | | | | | | | | Empyema. EcG: evidence of myocardial damage | | | |
| C | 34 | Rupt. int. meniscus | 8 | 30 | 12 | | | | | | | | | | | | | Chest: bila. chronic bronchitis—bilat. upper lobe fibrosis | 99° | 100 | 128/78 |
| D | 20 | Pneumonia | 5 | 11 | 6 | | | | | | | | | | | | | Rt. lower lobe pleuropneumonia | 104° | 120 | 125/70 |

Volume 104
Number 3

TABLE V

CIRCULATION TIME AS A PROGNOSTIC INDICATOR

| Case | Age | Diagnosis or Leading Symptoms | V.P. | S.T. | E.T. | Pulse | Temp. | Hb. | Blood Pressure | Roentgen Ray | EcG. | Admission Diagnosis | Final Diagnosis | Clinical Course |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 45 | Abd. pain, rigid abd. Subsidence of symptoms in two days Recurrence on fifth day postoperative | 6 | 23.5 | 9 | — | — | — | — | — | — | Perforacted ulcer | Perforated ulcer, myocardial infarct. | Death 12 hrs. postop. from myocardial infarction |
| 2 | 36 | Vaginal bleeding, fibroid uterus, cystocele and rectocele | Preop. 7.5 | 29 | 16 | 80 | | | 140/70 | Slight chr. bronchitic changes | *1st* Normal *2nd* Definite evidence of myocardial damage | Fibroid cystocele, rectocele | Myocardial degeneration, coronary sclerosis | In view of prolonged C.T. only plastic done (spinal); p.o. course characterized by precordial pain and medical shock |
| 3 | 50 | Questionable G-B disease | 12 | 21 | 9 | 80 | | | 92/70 | | | G-B disease | Myocardial failure | Died soon after oper. (heart stopped on table) |
| 4 | 47 | Adenoma-thyroid | 20 | 22 | 8 | 70 | | | 180/100 | | | Adenoma, thyroid | Adenoma, thyroid, myocardial failure | Sudden death, 12 hrs. postop. No local cause for death |
| 5 | 40 | Ruptured ulcer, and coronary art. thrombosis. Patient in collapse on admission | 0 | 31 | 11 | 120 | | | 70/50 | Chest—neg. | | Ruptured ulcer—coronary art. thrombosis | Ruptured ulcer, coronary thrombosis | Death 12 hrs. after adm. No surgery. Autopsy |
| 6 | 73 | Strangulated hernia | Preop. Postop. | 30 25 | 18 8 | 100 Dyspnea | 99.6° | | 185/95 | | Evidence of myocardial damage | Strangulated hernia, coron. art. disease, myocard. degener. | Same | Death fourth postop. day. Myocardial failure. Pulmonary edema |
| 7 | 50 | Ca. stomach | | 27 | | Preoper. | | | 84/62 | Gastric Ca. | Severe myocardial disease | Ca. stomach | Ca. stomach—myocardial failure | Gastro-enterostomy and death in 24 hrs. |
| 8 | 67 | Strangulated umbilical hernia | 8 | 19 33 | 10 | 80 24 hrs. p.o. 100 | 101.° | | 170/110 | | | Strangulated umbilical hernia | Myocardial failure, cerebral accident | Patient died suddenly when out of bed—2 wks. Postop. |
| 9 | 35 | Fibroid uterus | 7 | 13 | 6 | 80 | | | 130/80 | | | Fibroid uterus | Same | Uneventful recovery |
| 10 | 45 | Ca. rectum | 7 | 8 | 7 | 76 | | 50% | 140/80 | | | Ca. rectum | Same | 2 stage operation. Uneventful. Postoperative course |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 50 | Ca. uterus | 9 | 9 | 8 | 72 | N. | | 170/92 | | Ca. uterus | Same | Good operative reaction |
| | | 24 hrs. postop. | 13 | 10 | 7 | | | | | | | | |
| 12 | 40 | Acute cholecystitis | 9 | 17 | 7 | 100 | 101° | | 114/70 | | Acute cholecystitis | Same | Prolongation of s.t., but good reaction to operation, hrt. not investigated |
| | | 24 hrs. postop. | 13 | 5 | 7 | | | | | | | | |
| 13 | 48 | Fibroid uterus | 12 | 10 | 6 | 76 | 98.6° | | 120/70 | | Fibroid uterus | Same | Hysterectomy, uneventful recovery |
| | | 24 hrs. postop. | 12 | 11 | 6 | | | | | | | | |
| 14 | 45 | L. inguinal hernia hypertension | 11 | 9 | 7 | 70 | 99° | | 170/108 | | Hernia | Same | Uneventful postoperative course |
| | | 24 hrs. postop. | 7 | 12 | 7 | | | | | | | | |
| 15 | 43 | Common duct stone (very ill), jaundice | 8 | 13 | 7 | 100 | 102° | 75% | 130/82 | | Cholecystectomy, common duct drainage | Same | Uneventful recovery |
| 16 | 46 | Acute cholecystitis | 6 | 18 | 9 | 76 | 99° | | 110/70 | | Cholecystectomy, appendectomy | Same | Cholecystectomy — uneventful recovery |
| | | 48 hrs. postop. | 5 | 16 | 10 | | | | | | | | |
| 17 | 58 | L. inguinal hernia, emphysema, cyanosis | 11 | 14 | 7 | 68 | 98.6° | | | Postoperative pneumonia | L. ing. hernia | | Recovery and slight pulmonary complication. Excellent prognosis |
| 18 | 57 | Ca. breast, acute pleurisy and effusion | 7 | 8 | 4 | 80 | 98.6° | | 150/90 | | Ca. breast | Ca. breast and postoperative pleurisy | Uneventful recovery —complicated by pulmonary complication |
| 19 | 40 | Fibroid gallstones | 5 | 9 | 5 | 76 | 99° | | | | Hysterectomy, salpingo-oophorectomy, appendectomy | Same | Uneventful recovery following cholecystectomy, hysterectomy and appendectomy |
| | | 24 hrs. postop. | 8 | 10 | 10 | | | | | | | | |
| 20 | 28 | G-B disease | — | 15 | — | 80 | 98.6° | | 128/80 | | Cholecystectomy, appendectomy | Same | Cholecystectomy, uneventful recovery |
| | | Postop. | — | 15 | — | | | | | | | | |
| 21 | 50 | Hernia | 8.5 | 8 | 7 | 80 | 99.6° | | 118/90 Post-spinal | | Hernioplasty and spinal anesth. | Same | Uneventful recovery |
| 22 | 42 | Cholecystitis, acute empyema | 6 | 8.5 | 7.5 | 100 | 101.6° | | | | Cholecystectomy, appendectomy | Same | Cholecystectomy, uneventful recovery |
| 23 | 43 | Ca. rectum | 10 | 7 | 11 | 72 | 98° | 70% | | Chest—neg. | Ca. rectum | Same | Reactive well to surgery |
| 24 | 40 | Hysterectomy, appendectomy | 9 | 11 | 5 | N. | N. | | 130/80 | | Hysterectomy, appendectomy | Same | Uneventful recovery |
| 25 | 31 | Adenoma thyroid | 11 | 22 | 7 | | | | | | Adenoma thyroid | | 2 histories of prolonged c.t. where outcome was favorable |
| | | 5 days postoper. | 10 | 10 | 6 | | | | | | | | |

**Case D.**—A young man of 20, with a 24 hour history of right upper abdominal pain and cough. Temperature, 104°; pulse, 120. S. T. 11; E. T. 6, and venous pressure 5. Roentgenologic examination revealed a pleuropneumonia at the right base. This involvement was not associated with prolongation of the C. T.

*Comment.*—Eight cases with postoperative pulmonary complications were observed. These were confirmed in all instances roentgenologically and clinically in six. In seven of them, there was a definite prolongation of the C. T. In four nonoperative cases, in which pulmonary pathology was observed, a prolongation of the C. T. was observed in three. Our observations do not justify us, at the present time, in expressing a definite opinion as to the sequence of events, that is; whether the slowing of the C. T. precedes the establishment of the pulmonary complications or whether it is a result of the action of the pulmonary stasis on the heart muscle. These findings are at variance with those of other observers who found no changes in cases of pulmonary tuberculosis or lobar pneumonia. However, the mechanism involved in postoperative pulmonary complications is probably of a different nature than that involved in a classic pneumonia.

We have grouped the postoperative cases under one heading recognizing the differences in the clinical picture. We feel that these clinical entities may be different stages of one process. If the prolonged postoperative C. T. be an indication of clinically unrecognizable left heart weakness, therapeutic measures such as cardiac stimulation and hyperventilation of the lungs can be successfully employed to prevent the development of serious pulmonary complications.

*Prognostic Value of the Circulation Time Test.*—The preoperative estimation of myocardial sufficiency is of greatest value to the surgeon. The following 20 cases show the value of this simple test in the field of preoperative "risk" estimation. The first eight cases presented are illustrative of the bad postoperative prognosis that frequently accompanies prolongation of C. T.

**Case 1.**—A male, 45 years old, in apparent good health, with negative heart findings except for slightly muffled heart sounds. Clinical findings: Symptoms of ruptured gastric ulcer, C. T. 23.5 seconds. Simple closure of perforation. Death, six hours later. Autopsy: Fresh myocardial infarction.

**Case 2.**—A young woman of 36, mild diabetic, referred to surgery for hysterectomy and vaginal plastic. No cardiac complaints or pathologic findings. C. T. 29.5 seconds. Because of the increase in the C. T., only the vaginal plastic was done, under low spinal anesthesia. Immediately after operation, patient was seized with severe precordial pain, with radiation down left arm. Cardiovascular collapse. Electrocardiographic studies during convalescence revealed considerable myocardial damage.

**Case 3.**—Well preserved man of 50, operated on for gallbladder disease. C. T. 21.5 seconds. Death eight hours postoperative, apparently from cardiac collapse.

**Case 4.**—Woman of 47, with recurrent adenoma of thyroid, nontoxic. C. T. 22.3. Death, 12 hours postoperative. No evidence of hemorrhage or laryngeal obstruction. No autopsy.

**Case 5.**—Man, 40 years old, admitted to hospital with rigid abdomen and signs of vascular collapse. Complaint of substernal pain of 24 hour's duration radiating into

the epigastrium. No operation was performed. S. T. 31; E. T. 11. Death ten hours after admission. Autopsy findings: Ruptured duodenal ulcer and coincident myocardial infarction.

**Case 6.**—Man, 73 years old. Hypertensive. Strangulated direct inguinal hernia. S. T. 30; E. T. 18. Operation under local anesthesia. No shock. Death on fourth postoperative day with signs of progressive myocardial disease.

**Case 7.**—Man, 51 years old, with carcinoma of stomach. General condition appeared to be poor. S. T. 27. Gastro-enterostomy. Death, two days later. No evidence of peritonitis.

**Case 8.**—Man, 67 years old. Admitted with strangulated umbilical hernia, but in apparent good general condition. S. T. 33; E. T. 10. Uneventful postoperative course. Death on the fourteenth day, when patient was up and about.

Five of these eight cases appeared to be good risks, clinically, and yet succumbed postoperatively.

Cases 9 to 24 all had normal C. T. readings. These cases were subjected to major surgery of varied types as shown in Table V. The age group was similar to that of the first eight cases detailed. In the main, these patients were good risks clinically, though a few appeared to be bad risks. No mortality occurred.

**Case 25.**—Adenoma of thyroid in a woman 31 years old. S. T. 22, on admission. Five days postoperative, S. T. 10. Recovery uneventful. The possibility that the prolonged C. T. preoperatively was related to the adenoma of the thyroid has to be taken into consideration.

*Comment.*—The above cases were consecutive ones and the conclusion seems inevitable that the mortality in patients with prolonged C. T. is very high. Though some of these patients were obviously poor risks, others (and these constitute a large number) would clinically fall into the group of "fair surgical risks."

Early failure of the heart, particularly the left heart, is not always apparent on clinical examination. These patients may become the subjects for major surgical procedures, elective or mandatory. Prolongation of the C. T. may be the only indication of their precarious condition, and its recognition a life-saving factor in our operative endeavors. Where surgery is imperative, the surgeon is forwarned as to the status of his patient and proceeds accordingly. In elective cases, appropriate therapy such as rest, digitalization and weight reduction will be followed by a better prognostic outlook. It is natural that this test is particularly valuable in the older group.

*Venous Pressure Studies.*—Routine V. P. readings were performed on the patients subjected to these circulation tests. The method used was that of Taylor, Thomas and Schleiter.[6] Thirty-two readings on as many normal subjects varied from 5 to 15 cm. as follows:

In the instances of greatest postoperative change, no significant clinically recognizable events occurred. In a group of cases where C. T. readings were of great value in differentiating or establishing cardiac disease in the presence of abdominal symptoms, V. P. readings were of little aid. In eight cases where the C. T. was markedly prolonged, the V. P.'s were 6 in two

| Cm. | Patients |
|---|---|
| 5 | 1 |
| 6 | 4 |
| 7 | 6 |
| 8 | 7 |
| 9 | 2 |
| 10 | 3 |
| 11 | 1 |
| 12 | 5 |
| 13 | 1 |
| 14 | 1 |
| 15 | 1 |

Forty postoperative V. P. readings showed the following:

| Cm. | Patients |
|---|---|
| 3 | 1 |
| 4 | 4 |
| 5 | 2 |
| 6 | 2 |
| 7 | 9 |
| 8 | 4 |
| 9 | 4 |
| 10 | 4 |
| 11 | 2 |
| 12 | 2 |
| 13 | 2 |
| 14 | 2 |
| 16 | 2 |

In 24 instances, the pre- and postoperative V. P. readings showed the following changes:

| Variation in Cm. | Instances |
|---|---|
| 0 | 7 |
| 1 | 5 |
| 2 | 3 |
| 3 | 1 |
| 4 | 3 |
| 5 | 1 |
| 6 | 2 |
| 8 | 2 |

cases; 7 in one; 11 in one; 0 in one; 15 in one; and 20 in one case. Thus, in only three instances out of eight cases of definite cardiac disease, was there any definite change in the V. P. record. The patient who showed a V. P. of 0 was in pronounced shock. The patient in whom a reading of 15.5 occurred had myocardial changes and subsequently died from a cardiac lesion. The patient in whom a reading of 20 cm. was recorded had a large substernal thyroid adenoma and had a C. T. of 22. One case with a V. P. of 17 cm. died of pulmonary embolism on the 5th postoperative day. In two cases of postoperative pulmonary complications, there was a marked rise in the V. P.

*Comment.*—Venous pressure readings do not have the value that S. T. readings have for the surgeon. Unless the right side of the heart is in failure or latent failure, or there is a vascular collapse, the changes fall within normal range. Operative procedures do not seem to have any effect on the V. P. Changes in the V. P. may occur in postoperative pulmonary complications. It seems possible from our studies that patients with high V. P.'s may be predisposed to embolic processes in the lung or elsewhere. If further studies substantiate this supposition, it may become possible to segregate these patients in order that immediate embolectomy be performed when and if suspected and expected embolism occurs.

## CONCLUSIONS

A study of C. T. on a number of surgical patients is presented. It has been shown that the test for establishing the C. T. is simple and accurate. It is applicable as a routine measure for differential diagnostic purposes in upper abdominal and cardiac lesions. It is of inestimable help in evaluating the preoperative state of the patient. It was used as a means of investigating the postoperative pulmonary complications, and the effect of spinal anesthesia upon the cardiovascular system. Further studies along these lines to permit us to arrive at more definite conclusions are being undertaken.

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# BRIEF COMMUNICATIONS AND CASE REPORTS

## STREPTOCOCCIC MENINGITIS AND SEPTICEMIA

### RECOVERY AFTER TRANSFUSIONS FROM DONORS WHO HAD HAD SCARLET FEVER

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**Case Report.**—A married white woman, aged 28, was admitted to St. Margaret's Hospital September 15, 1935, because of bleeding from the uterus since an abortion induced two weeks previously. Temperature, 101.4° F. Pulse, 118. Respirations, 28. She was pale and weak. The uterus, palpated from the rectum, was about three times its normal size.

The morning following admission, her temperature was 99.2° F.; pulse, 112; respirations, 20. Hemoglobin, 40 per cent; erythrocytes, 2,290,000; leukocytes, 5,100; differential: polymorphonuclears, 48 per cent, 52 per cent lymphocytes. She was flowing profusely. Under spinal anesthesia, a mass of decidual tissue was removed, and the uterine cavity loosely packed with dry gauze. A transfusion of 600 cc. of citrated blood was given. That evening, her temperature rose to 104.6° F.; pulse, 126; respirations, 28.

For the ensuing seven days, her temperature varied between 101.8° to 105.0° F. She complained of severe headache, and of pain in the upper lumbar region. Blood culture September 18 showed a growth of Streptococcus hemolyticus. A transfusion was given daily for ten days, usually in the amount of 600 cc. The blood for eight transfusions was obtained from individuals who had had scarlet fever, although not recently; of six of these donors, two who stated that they had had the disease in severe form gave blood twice. It seemed to us that the therapeutic response was more marked when blood was transfused from the latter two donors.

Several herpetic vesicles appeared on the patient's lip September 20. Two days later, more developed in a patch 4 cm. in diameter near the umbilicus. Her headache became excruciating and her neck gradually became stiff. On September 23, opisthotonos was present. On that day, 50 cc. of cerebrospinal fluid was removed, which contained 7,250 cells per cc., almost all polymorphonuclear leukocytes. Culture of this fluid showed a growth of Streptococcus hemolyticus. Immediately after withdrawal of this fluid, the headache, backache, and rigidity of her neck were relieved. On the following day, her temperature dropped to normal, and at no time thereafter exceeded 100.0° F. No bacteria were obtained from a blood culture September 24.

The patient was kept in the hospital for 12 days after her fever subsided. She complained occasionally of headache in both parietal regions. She was allowed to get out of bed September 30, and returned to her home October 5. On October 18, she states that she still had an occasional headache and was easily fatigued, but was able to do her housework.

A discussion and bibliography of the use of scarlet fever serum (although all the cases of meningitis died), is given by: Thalhimer, W., and Levinson, S. O.: Pooled Convalescent Scarlet Fever Serum Treatment of Diverse Streptococcic Infections. J.A.M.A., **105**, 864–866, September 14, 1935.

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# STENOSIS OF GASTROJEJUNAL STOMA CAUSED BY RETENTION OF MURPHY BUTTON*

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## CASE REPORT

A MALE, aged 46, was admitted to Beekman Street Hospital August 4, 1933, because of a sudden collapse associated with profuse hematemesis. He had had two episodes of vomiting blood during the previous 24 hours, the passage of tarry stools for one week, and a ten year history of digestive discomfort. He was in moderate shock, pulse of 110, blood pressure 90/60, red blood cell count 3,000,000, hemoglobin 50 per cent.

He was placed on a supportive regimen for a bleeding peptic ulcer and, except for another massive hemorrhage on the sixth day, when the red blood cell count fell to 1,600,000 and the hemoglobin to 30 per cent, his condition gradually improved enough to permit a roentgenologic examination September 11. This revealed a large penetrating ulcer 4 cm. in diameter on the lesser curvature of the stomach in the region of the reentrant angle. A second examination, four weeks later, showed no decrease in the size of the lesion, and a suspicion of malignancy was entertained. An attack of paroxysmal tachycardia lasting 36 hours delayed operation until October 24, 1933, when exploration revealed an indurated, suspiciously malignant, penetrating ulcer 2.5 cm. in diameter at the reentrant angle of the stomach. A Bilroth II type of gastric resection was done 5 cm. above the level of the ulcer lesion, employing a Murphy button to effect a posterior no-loop gastrojejunostomy. This was used because of the high resection necessitated, and the desire to complete the procedure as expeditiously as possible because of the patient's unfavorable condition. The lesion proved to be a benign gastric ulcer.

For ten days the postoperative course was uneventful. Then the patient began to regurgitate small amounts of food and to vomit. Daily lavages and frequent small feedings improved these symptoms, which were thought to have been due to gastric atony and distention. Repeated roentgenologic examinations showed the Murphy button to be still retained in the gastro-enteric stoma and it was still there when he was discharged October 27, 1933.

Three months later (January 25, 1934), the patient was readmitted because of persistent regurgitation of food, frequent vomiting, increasing weakness and a loss of 15 pounds. Roentgenologic examination revealed no change in the position of the Murphy button. The patient continued to vomit and rapidly lost ground despite all supportive measures. Exploration was performed February 12, 1934. The Murphy button was found to be still retained in the gastrojejunal stoma. After freeing the anastomosis from the transverse mesocolon, an incision was made over its anterior aspect exposing the button. The cause of the obstructive symptoms became apparent. The intervening tissue which ordinarily sloughs away, due to pressure necrosis when the button is closed, had persisted as a viable diaphragm. Removal of the button, and the establishment of an adequate stoma by the suture method, was followed by an uncomplicated convalescence.

In the 1933 Year Book of Surgery, Dr. Evarts A. Graham remarked: "It is interesting to read that the Murphy button is still being used. One cannot resist the temptation to ask, why?" The superiority of suture methods over any mechanical device as a means of effecting intestinal anastomoses warrants their unquestioned use whenever feasible. However, it is our feeling, in spite of the complication illustrated by the present case, that there are occasions when the employment of the Murphy button may not only be

* Presented before the New York Surgical Society, October 9, 1935.

preferable but actually be indicated. In high gastric resections where a minimum of stomach remains, a suture anastomosis is technically difficult, if not impossible. In such instances, Murphy button anastomosis may be effected with greater facility and safety. There are occasions, also, where an intestinal resection must be completed as expeditiously as possible because of the condition of the patient due to gangrenous strangulation in elderly or toxic individuals, multiple gunshot wounds of the gastro-intestinal tract, or a sudden unfavorable change of condition during the course of operative procedure. A Murphy button anastomosis may save much valuable time and be the factor determining a successful outcome. These indicated instances—and we believe the present case was one—occur frequently enough in any active gastro-intestinal or acute surgical clinic to convince us that the Murphy button still retains a place of usefulness and is not as yet to be relegated to the historic curiosities of the past.

Discussion.—Dr. John D. McCreery (New York) stated that insofar as he himself had used it or had seen it used, the indications for the Murphy button have been rare. Its use has been due, in large part, to the influence of tradition. The time saved by its employment is not sufficient to make it preferable to suture anastomosis with the few extra moments the latter procedure requires, in view of the number of cases reported in which the button has been retained or stenosis has followed its use.

Dr. Richard Lewisohn (New York) had observed the rise and fall in the popularity of the Murphy button during a period of about 40 years. In the early part of this century the button was most popular and was used for all forms of gastro-enteric and entero-enteric anastomoses. During the last decade, however, most surgeons had discontinued its use. He agreed with Doctor Mage that the button has a very important place in gastric surgery and said he did not know how a very high subtotal gastrectomy could be performed without the button. Unless it is used in these high resections, it is necessary to make an antecolic anastomosis with entero-anastomosis which requires at least half an hour. With the aid of the button a safe anastomosis can be effected in a few minutes.

Undoubtedly the button may occasionally cause complications. Two very interesting cases had been reported by him 20 years ago under the title: "Stenosis of Stoma Simulating Recurrence of Carcinoma of the Stomach." In these cases recurrent symptoms (vomiting, loss of weight, *etc.*) occurred six months after the primary gastric resection. Reoperation showed that these symptoms were not due to a recurrent carcinoma. In one case the button had remained *in situ*, in the other the stoma had narrowed down to the size of a pencil.

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## RECURRENT PROLAPSE THROUGH THE STOMA OF A COLOSTOMY

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Recurrent prolapse through the stoma of a colostomy is a trying complication. Loose mesocolic attachment and unsatisfactory parietal fixation

may be easily corrected surgically, but success is problematical where the colostomy fails because of infection, poor cooperation, age, thin atrophic abdominal wall, and gaping orifices in weak fascial structures. Such a case was encountered which entailed several surgical failures complicated with wound infection, and which was successfully treated by the following procedure.

CASE REPORT

A white male, aged 64, was admitted to the Jeanes Hospital on October 24, 1930. He was mentally disturbed, hypertensive and senile. He had a Kraske operation performed for a large rectal carcinoma, subsequently complicated by a saphenous phlebitis. On August 24, 1931, a large prolapsing colostomy mass was found. At operation, the fascia appeared widely separated. The intestine was returned to the abdomen and fascia and muscle layers carefully approximated. Recurrence was rapid and by September 15, 1933, the everted intestine occupied an abdominal quadrant. Five weeks after a third operation, another prolapse was discovered. These three failures, the thin atrophic fascial walls, danger of infection and the mental irresponsibility of the patient, led to the institution of the following procedure. The patient forcefully extruded as much intestine as possible. A finger was then inserted into the gut lumen to determine the presence of any additional loop of intestine within the extruding mass. A semisolid rubber tube, 2 cm. in diameter, was then introduced into the lumen beyond the abdominal wall, and fine rubber jute tubing wound tightly over mucosa about the base of the mass and clamped. Five days later, the non-viable material was removed by cautery, one day later the tube and ligature were removed without bleeding or infection. Healing followed rapidly, and thus far there has been no recurrence of the prolapse. Rather generalized cramping and shooting abdominal pains developing 24 hours after the ligation were not associated with hyperperistalsis, vomiting or other features of acute intestinal obstruction. For two preoperative days, and until the termination of the ligation, the patient was kept on a liquid diet. During the six day period, the colostomy tube was frequently flushed out with saline solution, alternating with liquid petrolatum.

This method of treating prolapse through the stoma of a colostomy depends on securing the maximum extrusion of intestine possible previous to ligation, while inclusion of an extra loop of intestine must be guarded against by careful preliminary examination.

We subsequently learned that Doctor Reid had reported the employment of this procedure in the treatment of irreducible prolapse of the rectum in the American Journal of Surgery, p. 359, May, 1933.

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## ILEOCECAL RESECTION FOR ACUTE DIVERTICULITIS OF SOLITARY DIVERTICULUM OF ASCENDING COLON*

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NEW YORK, N. Y.

**Case Report.**—A woman, 35 years old, was admitted to Lenox Hill Hospital October 15, 1934. For two years she had complained of occasional sharp pains in the right lower quadrant with some abdominal distention. For some months previous to her admission she had had a vague feeling of discomfort in the abdomen, particularly

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in the right lower quadrant. She had been very constipated, and complained of distention, headache, vertigo, general malaise, nervousness and depression. On the day previous to admission she had an attack of abdominal cramps, accompanied by abdominal distention. She did not vomit, and her bowels moved several times, accompanied by large amounts of flatus as the result of catharsis, and was somewhat relieved. There was definite tenderness in the region of McBurney's point, and a finger-like sensitive mass was palpable in this region. There was no rigidity. Vaginal examination showed some tenderness in the right fornix. Temperature, 100.4°. Leukocytes, 18,000; polymorphonuclears, 85 per cent (immature 17 per cent); lymphocytes, 6 per cent; monocytes, 9 per cent. She was considered to be suffering from acute appendicitis.

FIG. 1.—Photograph of resected and opened ileocecal portion of intestine showing opening of diverticulum on inner side of gut above ileocecal valve.

*Operation.*—A right lower rectus incision was made and before opening the abdominal cavity, the mass that was previously palpated could be very distinctly felt through the peritoneum. There was a moderate amount of free clear serous fluid in the abdominal cavity. Lying below the cecum was a very long, large, coiled, but not acutely inflamed appendix. On the inner aspect of the ascending colon about three-fourths of an inch above the ileocecal valve was a hard, tumor-like mass, involving the gut and the adjacent mesentery, about the size of an egg. It was quite movable. Its feel and appearance suggested an inflammatory rather than a neoplastic growth. On palpating from the outside by invaginating the gut, a large, round, crater-like defect was noted on the inner wall of the gut which had all the characteristics of a punched-out ulceration. It was large enough to permit the entrance of the tip of the thumb. The edges were apparently smooth, not everted and not indurated. In the adjacent mesentery,

running almost down in the root, were a number of slightly enlarged, fairly firm lymph nodes, which also suggested inflammatory involvement rather than neoplastic metastases. There were no signs of any other metastases in the abdominal cavity. There was no evidence of diverticulosis in any other portion of the colon.

A diagnosis of a solitary, penetrating ulcer, probably benign, of the ascending colon, was made, and an ileocecal resection with a lateral isoperistaltic ileocolostomy between the ileum and the lower portion of the ascending colon was performed. Gross examination of the specimen confirmed the impression that the lesion was not malignant (Fig. 1). Microscopically it was shown to be an acutely inflamed false diverticulum of the ascending colon with acute peridiverticulitis and pericolitis with acute lymphadenitis of the mesenteric lymph nodes, the diverticulum having worked its way between the leaves of the mesentery. Its cavity was lined with mucous membrane. The appendix showed chronic appendicitis and peri-appendicitis. There was no evidence of malignancy.

*Postoperative Course.*—For a week there was some distention, vomiting, hiccough and cramps, but with good pulse and very little temperature. After that her bowels began to move freely and her convalescence was quite uneventful. The abdominal wound healed by primary union with no trace of leakage from the intestinal suture line. She has been perfectly well since.

Diverticulitis in a solitary diverticulum in this region must be extremely rare, and naturally will invariably be confused with acute appendicitis. In a search of the literature no record of a solitary diverticulum in just this region has been found, but in a report by H. Thomsen,[1] on solitary diverticula of the cecum, he cites eight cases found by him in the literature, and presents three additional instances. The ages of the patients varied from 20 to 60. They appear singly or, at the most, as two or three small pouches, the size of a pea to that of a walnut, on the anterior wall of the cecum. The symptoms are identical with those of acute appendicitis, and the diagnosis in all cases has been acute appendicitis.

## REFERENCE

[1] Thomsen, H.: Solitary Diverticula of the Cecum. Hospitalstidende, **78**, 45, January 8, 1935.

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